

COOPERATIVE INSTITUTE FOR MARINE
AND ATMOSPHERIC STUDIES

CIMAS

Fourth Year Annual Report

NOAA Cooperative Agreement NA17RJ1226

2004. - 2005

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UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL OF MARINE
AND ATMOSPHERIC SCIENCE



Hurricane Wilma, October 24, 2005

**Cooperative Institute of Marine
and Atmospheric Studies**

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EXECUTIVE SUMMARY

The Cooperative Institute of Marine and Atmospheric Studies (CIMAS) is a research institute at the University of Miami in the Rosenstiel School of Marine and Atmospheric Science (RSMAS), jointly sponsored by the University and the National Oceanic and Atmospheric Administration (NOAA). CIMAS works closely with two local NOAA laboratories: the Atlantic Oceanographic and Meteorological Laboratory (AOML) and the Southeast Fisheries Science Center (SEFSC). CIMAS carries out research under six Themes:

Theme 1: Climate Variability

Theme 2: Fisheries Dynamics

Theme 3: Regional Coastal Ecosystem Processes

Theme 4: Human Interactions with the Environment

Theme 5: Air-Sea Interactions and Exchanges

Theme 6: Integrated Ocean Observations

All research carried out in CIMAS is closely linked to the NOAA Strategic Goals.

The research program in CIMAS continues to show steady growth. During FY 2004-2005 a total of 121 persons were involved with CIMAS in various capacities, including full time personnel, students and support staff. Of these, 83 received over 50% of their support from NOAA sources; 51 were linked to activities in AOML and 32 with SEFSC. The Research Associates/Scientist ranks, those personnel who work closely with AOML and SEFSC, grew to 44, an increase of 30% over the previous year.

Total funding in FY 4 was \$8.6M, an increase of 17% over Year 3, and 38% over that in FY 1 of the Agreement. The strongest and steadiest growth continues to be under Task 2 which supports CIMAS employees who work closely with AOML and SEFSC. Task 2 funding in FY 4 was \$2.7M, twice that in FY 1. Research funding (Task 3 and Task 4) in FY 4 was \$3.8M, approximately the same as in FY 3; the average funding in YR 3 and 4 is substantially higher (55%) than the average of the first two years of the program. Much of this increase is due to the stepped up research activities carried out in conjunction with the South Florida - Everglades Restoration. There is also substantially more research in the areas of climate, weather, and hurricane research. We also continue to see steady growth in fisheries-related research.

The research program in CIMAS continues to yield many exciting results. Here we highlight some of our achievements. These are selected to be representative of the wide range of activities carried out in CIMAS. A more extended collection of highlights can be found in the body of the Report.

- Dust-laden African air outbreaks tend to suppress the development of tropical storms and hurricanes; we have developed new techniques to track these events with satellites.
- A new model routine provided real-time guidance to the NOAA G-IV aircraft on a regular basis during the 2004 and 2005 hurricane seasons; aircraft observations collected in model-targeted areas produced marked improvements in operational hurricane track forecasts.
- We used the Weather Research and Forecast Model (WRF) model to study some of the fundamental inner-core processes in tropical cyclones; we find that instabilities may explain why spiral bands are so ubiquitous in tropical cyclones.
- We carried out the first direct measurements of air-sea latent heat fluxes under hurricane conditions; these data should lead to improved storm forecasts.

Executive Summary

- We find that currently-used ocean surface mixing models have a systematic bias in the initial model temperature structure. These biases reduce the accuracy of hurricane forecasts.
- The airborne Stepped-Frequency Microwave Radiometer (SFMR) has been successfully used to measure wind speed in hurricanes and will be transitioned to routine operations.
- A study of inter-model differences in cloud feedback finds that they are the largest source of uncertainty in current model predictions of climate change due to increasing greenhouse gases; this points the way to improving climate modeling.
- Satellite measurements identify a distinct upper tropospheric moistening trend over the period 1982-2004 that is accurately captured by climate model simulations; this observation lends further credence to model projections of future global warming.
- A warm water pool in the eastern North Pacific, the Gulf of Mexico and the Caribbean Sea is an important source of moisture for the surrounding land masses; it influences rainfall and the frequency of hurricanes.
- An adaptive observing strategy model study over the North Pacific shows improved data yields which are expected to lead to improved forecasts for North America.
- By assessing the ocean carbon inventory changes since the 1980s, we find that inorganic carbon has increased at a rate consistent with the anticipated impact of the anthropogenic carbon source changes and the associated climate change.
- We developed ENSO-based forecasts coupled to economic and statistical models that are tailored to specific crops grown in the SE US; these web-delivered products include whole-farm risk models which aid the farmer in making decisions.
- Feeding-hook tests show that the by-catch of sea turtles, an endangered species, can be greatly reduced by making some relatively simple changes.
- Hurricanes have a dramatic impact on South Florida coastal and bay waters and their ecosystems - Hurricane Irene produced the lowest salinity patterns of the year.
- Elkhorn coral, a dominant framework builder on Florida and Caribbean reefs, has declined 90% since the 1980s and it is currently being proposed for listing as 'threatened' under the Endangered Species Act. While disease has had the greatest impact on the corals, hurricanes can be devastating - Hurricane Dennis caused heavy and widespread coral fragmentation.
- We have developed techniques, based on the measurement of trace elements in the otoliths (ear bones) of fishes, which enable us to identify the nursery habitat of a fish, information that is essential for management strategies.
- We developed a fast, simple, and novel molecular approach to detect fecal contaminants in coastal waters; this will facilitate management decisions regarding human access to contaminated marine waters.
- We are developing marine biosensors to measure DNA via cutting-edge electrochemical detection methods for use in a portable instrument that yields improved, simultaneous detection of human pathogens and microbial indicators of polluted waters.

CIMAS is proud of the accomplishments of the past year in research, education and outreach. We look forward to continued cooperation with our colleagues in NOAA.

CIMAS MISSION AND ORGANIZATION



Above, a view of Virginia Key looking toward the northwest, showing the Rosenstiel School, foreground, the NOAA Atlantic Oceanographic and Meteorological Laboratory, center, and the Southeast Fisheries Science Center of the National Marine Fisheries Service (right center, above the causeway). Virginia Key is about 3 miles east of downtown Miami, Florida.

CIMAS, the University, and NOAA

The Cooperative Institute of Marine and Atmospheric Studies (CIMAS) is a research institute at the University of Miami in the Rosenstiel School of Marine and Atmospheric Science (RSMAS). CIMAS is sponsored jointly by the University of Miami and the National Oceanic and Atmospheric Administration (NOAA) through NOAA's Office of Oceanic and Atmospheric Research (OAR), a line office in NOAA also known as "NOAA Research". CIMAS was established in 1977 through a Memorandum of Understanding between NOAA and the University of Miami. It is one of twelve such Cooperative Institutes nationwide.

The CIMAS Vision:

- To become a center of excellence in Earth Systems Science and the human interactions with the Earth System;
- To serve as a means of using this knowledge to improve and protect our environment and to use it more effectively and benevolently;
- To convey this knowledge to the public through education and outreach.

The CIMAS Mission:

- To conduct research in the terrestrial, ocean, and atmospheric environment within the general context of NOAA's mission;
- To focus on the physical, chemical, and biological interactions between and among these environments;
- To understand the role of humans in affecting these environments and the impact of the changes in the environment on humans;
- To facilitate and participate-in education programs that are grounded in advanced Earth System Science.

How CIMAS Carries Out Its Mission

CIMAS serves as a mechanism to promote synergisms between University scientists and those in NOAA. Most of our research is related to programs in OAR and in the National Marine Fisheries Service (NMFS). Over recent years we have had increasing interactions with NOAA's National Environmental Satellite Data and Information Service (NESDIS). Most activities in CIMAS are associated with research programs at the local NOAA Atlantic Oceanographic and Meteorological Laboratory (AOML) and the Southeast Fisheries Science Center (SEFSC) both of which are located on Virginia Key in close proximity to the CIMAS/RSMAS campus.

CIMAS addresses issues of national interest within the context of NOAA's missions of environmental prediction and stewardship. CIMAS accomplishes this:

CIMAS Mission and Organization

- By fostering joint projects between University of Miami scientists and those employed at the NOAA laboratories;
- By providing a mechanism for engaging undergraduate students, graduate students and post-doctoral fellows in the research at these laboratories;
- By arranging for short-term visiting specialists to enhance the general effort in relevant research areas through short term consultations and seminars or by arranging for their involvement in ongoing projects for longer time periods;
- By providing training for personnel in various areas of research in marine and atmospheric science.

CIMAS enhances NOAA-University cooperation and thus promotes both the quality and attractiveness of the local NOAA laboratories as a scientific working environment. It also serves to increase the breadth of University activities in research areas that are complementary to NOAA's mission.

The Link between CIMAS Research and NOAA Goals

CIMAS research and its scientific objectives are guided by the general objectives of NOAA's Strategic Plan for FY 2005-2010. NOAA identifies four mission goals:

1. Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.
2. Understand climate variability and change to enhance society's ability to plan and respond.
3. Serve society's needs for weather and water information.
4. Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation.

NOAA's Mission Goals are consistent with the broader mission of CIMAS in the Earth System Sciences. Each research project in CIMAS is associated with a specific NOAA mission goal.

The Administration and Governance of CIMAS

The organization of CIMAS is designed to reflect the joint interests of the University and NOAA in carrying out the CIMAS Mission. In accordance with the MOU, the Director of CIMAS must be a faculty member of the University. Many aspects of the governance of CIMAS are dealt with in consultation with the CIMAS Fellows who act much like a Board of Directors. Fellows are scientists of established national or international standing who hold regular teaching or research faculty appointments in the University or who are staff members of NOAA. The Fellows play an important role by providing guidance to the Director of CIMAS in matters regarding the promulgation of research programs. One of the Fellows' most important tasks is to work on the development of CIMAS activities that benefit both University and NOAA research objectives. At present there are 19 CIMAS Fellows. We strive to maintain a numerical balance between in the membership with approximately half University faculty and half NOAA employees.

CIMAS activities fall into four Task categories. The administrative functions of CIMAS are carried out under Task I with funding provided by both the University and NOAA. Most research activities are carried out under Task II wherein CIMAS provides highly specialized research scientists who work on research projects carried out in NOAA's Miami laboratories. The expertise of these CIMAS employees complements that present in NOAA and the University. CIMAS employees provide support that is essential to the success of specific activities or projects under the collaborative research themes of the Institute.

Research programs in CIMAS are carried out under Task III and Task IV. These provide funds to University faculty and scientists to support research on CIMAS themes. Support for specific projects under these tasks is based on proposals submitted to specific NOAA units or to programs in response to a general announcement of opportunity. Task 3 encompasses activities of CIMAS scientists that are carried out in cooperation with the personnel at the local NOAA laboratories in Miami. Under Task 4 are projects that support or complement activities at NOAA laboratories other than those located in Miami.

PERSONNEL

Distribution of Personnel

CIMAS personnel participate in a wide range of NOAA-related activities. During FY 2004-2005 a total of 121 persons were involved with CIMAS in various capacities. Of these, 83 received over 50% of their support from NOAA sources. Table 1 shows the distribution of personnel by category and by their association with the local NOAA laboratories. Of the 83 who receive over 50% NOAA support, 51 are associated with AOML and 32 with SEFSC.

Table 1: CIMAS Personnel 2004 – 2005:

Personnel				
Category	Number	B.S.	M.S.	Ph.D.
Research Associate/Scientist	40	19	14	7
Visiting Scientist	8			8
Postdoctoral Fellow	7			7
Research Support Staff	23		1	1
Administrative	5			2
Total (> 50% support)	83	19	15	25
Undergraduate Students	5			
Graduate Students	11	6	5	
Part-Time (<50% NOAA Support)	3	2	1	
NOAA Lab Association	51-AOML 32-SEFSC			
Obtained NOAA Employment within the last year	3			

Research Associates/Scientists are those employees under Task 2 who work closely with the local NOAA laboratories. There has been a steady growth in Task 2 personnel in the middle and late 1990s. During the first three years of the current Cooperative Agreement Task 2 personnel levels had remained relatively steady – about 34. In FY 4 the number increased sharply to 44. Of this total 40 are full time employees who received over 50% of their funding from NOAA sources.

CIMAS Research Associates/Scientists are hired into a well-delineated series of categories that allow for professional advancement in the research ranks. There is a sequence of five positions targeted for advanced technical or scientific staff who are required for the support of research activities at the University. Advanced education, continuing professional achievement, and/or increased experience are the basis for advancement to a higher-level position. The progression order is: Research Associate, Senior Research Associate, Assistant Scientist, Associate Scientist, and Scientist. The “Scientist” ranks (Assistant Scientist, Associate Scientist, Scientist) are

Personnel

structured to parallel those of the research faculty at the University (i.e., Assistant Research Professor, Associate Research Professor, Research Professor).

There are a total of 7 Postdoctoral Fellows. Postdocs have become an important part of the CIMAS employee pool during the current Cooperative Agreement with numbers usually in the range of 7 to 9.

Research Support Staff are temporary employees, hired for the duration of specific projects. These include persons from a variety of backgrounds including local high schools as a part of outreach programs.

It should be noted that although CIMAS has the status of a division in the School it has no faculty. School faculty participate in CIMAS activities in many ways, but they hold their primary appointment in one of the School academic divisions. These faculty are not counted in the listing of persons associated with CIMAS except for those who serve as Fellows. Similarly, graduate students who work on CIMAS programs have their primary affiliation with an academic division which has the ultimate responsibility for overseeing the students' academic performance and the granting of degrees.

CIMAS Fellows

Many faculty participate in CIMAS as Fellows who play a role in the governance of the Institute. At present there are 19 CIMAS Fellows. In addition to the regular members of the Fellows, there are three ex officio members, the Dean of RSMAS (O. Brown) and the directors of the two local NOAA laboratories (P. Ortner, AOML; N. Thompson, SEFSC). A list of the CIMAS Fellows membership is shown in the Fellows section of this report along with their affiliation. At present 12 Fellows are University faculty and 7 are NOAA employees. We normally strive for an approximately equal balance of University and NOAA members. To this end we expect to add additional NOAA scientists to the Fellows during the coming year.

CIMAS Staff

CIMAS staff consists of the Director, Joseph M. Prospero, and the Associate Director, Claes Rooth. Both hold their primary appointments in School academic divisions. In addition there are three full-time administrative personnel.

Transition to Federal Positions

During the past year three CIMAS employees assumed positions as Federal Employees at the local NOAA laboratories. Since the start of the current Cooperative Agreement a total of seven have assume Federal positions in the local laboratories.

Degree Distribution of CIMAS Employees

The distribution of degrees amongst CIMAS personnel engaged in NOAA-related research in 2003-2004 is shown in Table 2.

Table 2: Degree Status of CIMAS Employees

Category	Number	B.S.	M.S.	Ph.D.
Research Associate/Scientist	40	19	14	7
Postdoctoral Fellow	7			7
Research Support Staff	23		1	1
Part-Time (under 50% NOAA Support)	3	2	1	
Graduate Students	11	6	5	
Undergraduate Students	5			
Totals	89	27	21	15

Demographics of CIMAS Employees

The employees in the Research Associate and Research Scientist ranks have a rather diverse demographic profile. The population is 40% female. Foreign-born individuals make up 47% of the personnel; of these Hispanics make up 28% of the ranks; Asian and Pacific Islander, 13%. The population of CIMAS is relative young with a average age of 36.

FUNDING

General Funding Trends

CIMAS continues to show steady growth in its funding. In FY 4, funds from all sources totaled \$8,550,287. A summary of CIMAS funding in FY 4 is shown in Table 1 which also shows the contribution from the University in support of CIMAS administration. For comparison purposes the table also shows funding for first three years of the Cooperative Agreement.

Table 1: CIMAS Funding Under the Cooperative Agreement

	Task I	Task II	Task III	Task IV	UM Admin	Total
Year 1	1,620	1,434	2,604	320	200	6,179
Year 2	1,381	2,059	1,444	625	190	5,699
Year 3	700	2,435	3,548	413	205	7,301
Year 4	1,847	2,701	2,863	945	205	8,550

The history of Total funding is shown graphically in Figure1. Total funding from all sources in FY 4 increased by about 1.3M (17%) over Year 3, and by about 2.4 M (38%) over FY 1 of the program.

The sources of funding are shown in a pie chart, Figure 2. OAR is clearly the dominant source of funding, providing 52% of the total funds with NMFS second at 26%. NOAA sources provide 93% of the total CIMAS funding. Of the total OAR funding, 36% comes from the Office of Global Programs. We reiterate that since CIMAS has no faculty, grants obtained from sources other than NOAA normally do not pass through NOAA but rather go to the divisions in which the faculty reside.

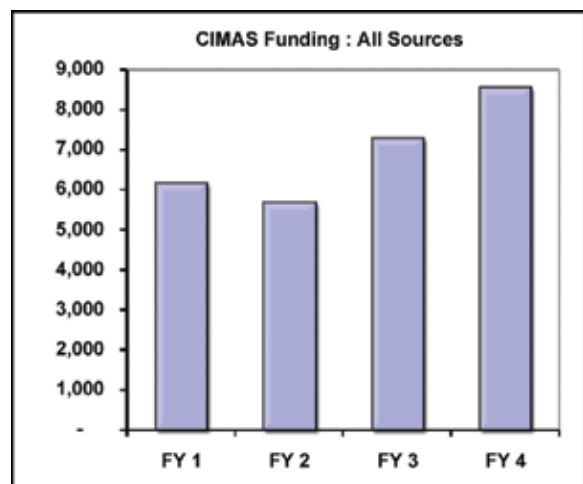


Figure 1: (top) CIMAS funding from all sources

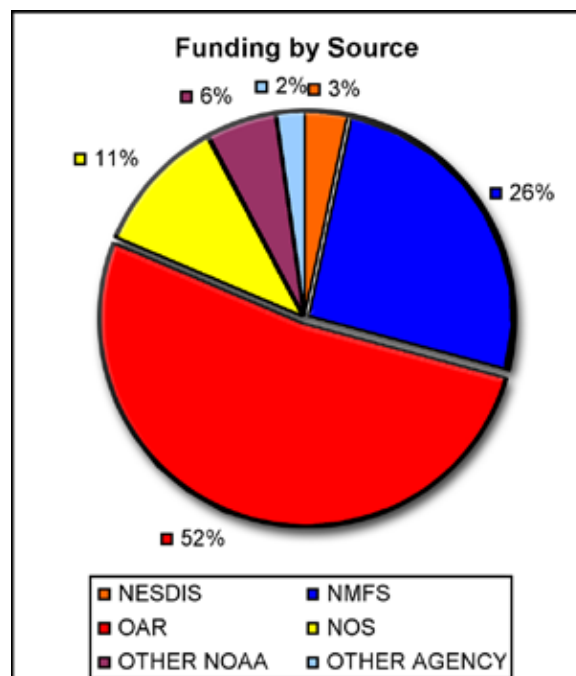


Figure 2: (right) Funding by NOAA Line Office Source and Other Sources

Funding Trends by Task

CIMAS activities are administratively grouped under four distinct Tasks that are related to different aspects of the CIMAS mission.

- Task 1 provides the administrative structure for the Institute and includes support for limited-term postdoctoral research associates, graduate students and limited-term collaborating research scientists from outside Miami. The University contributes to the administrative support of CIMAS in its role as a Division in the School. Task 1 also provides travel expenses and honoraria for short-term visits by scientists. CIMAS has an active Visiting Scientist program.
- Task 2 provides support for highly specialized research scientists who are employed by CIMAS to complement existing expertise at NOAA and the University in the collaborative research themes of the Institute.
- Task 3 and Task 4 encompass the directed research programs of CIMAS. These provide support for research in CIMAS themes by University faculty, scientists and students. Task 3 encompasses activities of CIMAS scientists that are carried out in cooperation with the personnel at the local NOAA laboratories in Miami. Under Task 4 are projects that support or complement activities at NOAA laboratories other than those located in Miami. The indirect cost rates for these two tasks differs in recognition to the direct funding support that CIMAS receives under Task 1 from the local NOAA laboratories.

The history of Task 1 funding over the first four years of the Cooperative Agreement is presented in Figure 3. Year 4 shows a sharp increase over Year 3 which was anomalously low. Nonetheless Year 4 is 50% higher than the average of the first three years of the Cooperative Agreement.

The School contributes to the funding of administration costs under Task 1. In Year 4, the contribution was \$0.205M, or about 10% of the total Task 1 related activities.

The distribution of NOAA Task 1 funding is shown in Figure 4. The total Task 1 budget, \$1.464M, does not reflect the \$0.205M contribution from the UM to Task 1 which is used primarily to support the salaries of the staff. The largest expenditure is for Postdoctoral Fellows. "Administration", "Temporary Staff" and "Other" each account for 21%. "Temporary Staff" are persons who are hired on a temporary basis to support research activities in CIMAS. "Other" includes: travel associated Task 1 scientists, students, visitors; new-hire expenses, consulting agreements, and supplies.

The history of funding for the Research Associate/Scientist program (Task 2) is shown in Figure 5. There has been steady growth in Task 2 reflecting the growth of research personnel in CIMAS. The past year saw a substantial increase in Task 2 funding with much of the growth through the SEFSC.

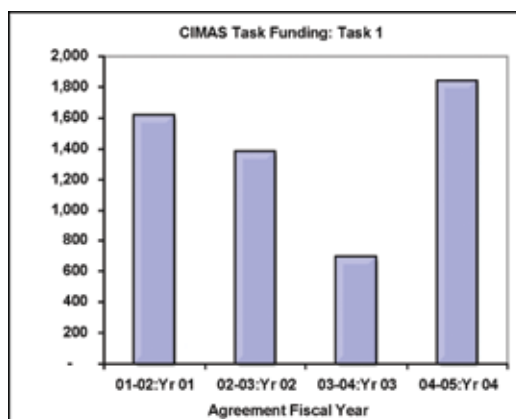


Figure 3: History of Task 1 Funding

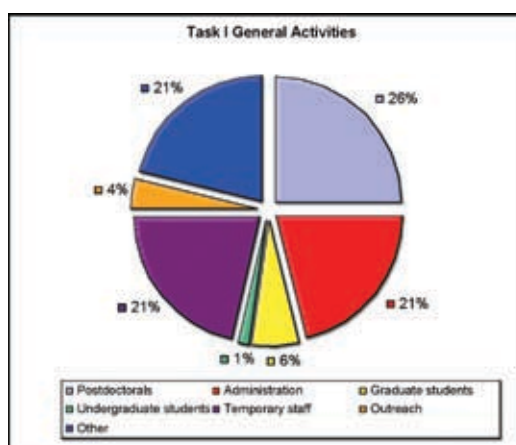


Figure 4: Distribution of Task 1 Funding

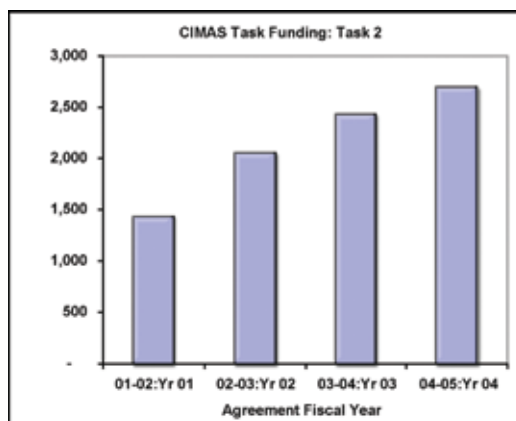


Figure 5: History of Task 2 Funding over the Cooperative Agreement

The history of research funding (Task 3 and Task 4 combined) is shown in Figure 6. There has been a substantial growth in funding over the four years of the Cooperative Agreement. In Year 3 and Year 4 funding was essentially unchanged but the average, \$3.879M, was 55% greater than the average of the first two years of the Agreement. The increase in Year 3 and Year 4 reflect to a large extent the increased research associated with the South Florida - Everglades Restoration program and also in the areas of weather-climate-hurricanes.

Funding By Theme

Figure 7 shows the percentage of Task 3 and Task 4 funding that is expended in the CIMAS Themes. **Theme 3:** Regional Coastal Ecosystem Processes is the most active, reflecting the large effort associated with the South-Florida Everglades Restoration. **Theme 4:** Human Interactions with the Environment is second. Again, this reflects the heavy emphasis on research on regional waters that are impacted by human activities. Third is **Theme 1:** Climate Variability. **Theme 2:** Fisheries Dynamics and **Theme 5:** Air-Sea Interactions and Exchanges are comparable at 12%. The activity in Theme 5 reflects the increased research related to hurricane research.. Note that this figure only shows the distribution of funding under Theme 3 and Theme 4; it does not show the funding that supports Task 2 personnel, many of whom carry out research in programs that fall under the CIMAS Themes. No funding is indicated for **Theme 6:** Integrated Ocean Observations despite the fact that a large number of CIMAS Task 2 employees are involved in this research area which takes place entirely in NOAA AOML.

In closing we emphasize once again that there are a substantial number of research programs carried out by RSMAS faculty that are complimentary to the NOAA-supported CIMAS-linked programs but supported by other agencies. The grants obtained by these faculty are credited to the academic division in which they reside. Consequently there is considerable “leveraging” of NOAA funds across the campus but this does not show up in the present accounting.

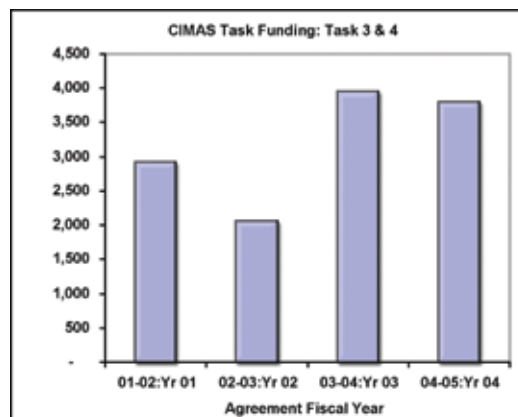


Figure 6: History of CIMAS Research Funding (Task 3 and Task 4)

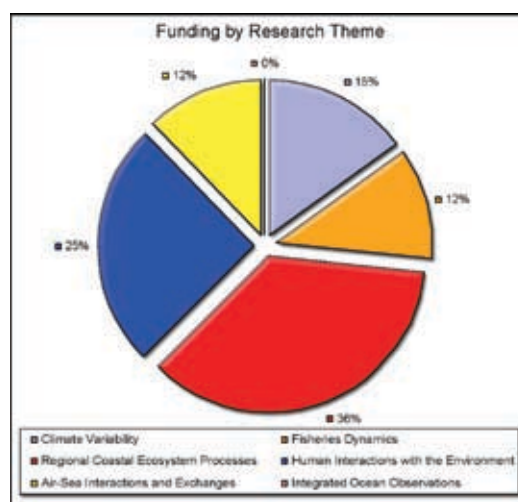


Figure 7: Percentage of Task 3 and Task 4 (Research) funding in the CIMAS Themes.)

RESEARCH THEMES OVERVIEW

Organization of CIMAS Themes

Scientific activities in CIMAS are organized under broad Research Themes. The selection of Theme topics is guided by the major environmental issues that confront our nation today. CIMAS' Research Themes and their scientific objectives complement those in NOAA's Strategic Plan. Specific goals are set in the context of the research activities and expertise resident in the University and the local Miami laboratories of NOAA. Under the current Cooperative Agreement, scientific activities in CIMAS are carried out under six themes.

Theme 1: Climate Variability

Theme 2: Fisheries Dynamics

Theme 3: Regional Coastal Ecosystem Processes

Theme 4: Human Interactions with the Environment

Theme 5: Air-Sea Interactions and Exchanges

Theme 6: Integrated Ocean Observations

Theme 1: Climate Variability

- ***Investigate the dynamics of the ocean and the atmosphere and the ways in which they interact on interannual and longer-scales and they link to climate variations.***

The major challenges of climate research today are to accurately characterize climate variability on time scales ranging from weeks to centuries, to detect trends in climate, and to identify the factors causing those changes, especially those deriving from human activities. Theme 1 research focuses on climate variations that occur on an interannual-to-longer time-scale. The objective is to understand the dynamics of oceanic and atmospheric processes that affect climate variations. The ultimate goal is to increase our capability to predict climate through the use of models.

The CIMAS program places emphasis on systematic analysis of environmental data sets which are very large and require special processing techniques. These consist of specific diagnostic studies as well as fundamental research into the principles of analysis. The CIMAS effort, combined with a continuing commitment to climate-oriented long-term observations of oceanic transport processes, contribute to the development of climate-prediction capabilities and to the assessment of climate change.

RSMAS pursues a vigorous program in atmospheric and ocean chemistry as related to climate processes and their variability. Research is underway with regards to the role of chemistry in radiative energy transfer processes by direct effects as well as indirect aerosol effects that involve the modification of oceanic cloudiness. Recently RSMAS has expanded its research capability in tropical meteorology; this will enhance the CIMAS mission in aspects of tropical atmospheric processes that relate to climate variability and to activities in the AOML Hurricane Research Division.

Because climate and climate variability are fundamentally global-scale phenomena, CIMAS research activities often involve strong interactions with the national and international research communities. To this end, CIMAS plays a role in fostering international cooperation. The major focus is with individuals and institutions in Latin America in the area of tropical air-sea interaction and in Europe with regard to research into the climatic role of the subtropical and tropical Atlantic circulation.

Theme 1 activities contribute to NOAA Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond.

Research in this theme is consistent with three NOAA Mission Strategies:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Understand and describe how natural systems work together through investigation and interpretation of information.*
- *Assess and predict the changes of natural systems, and provide information about the future.*

Theme 2: Fisheries Dynamics

- ***Enhance our understanding of fisheries and ecosystem dynamics so as to improve the management of fisheries and marine protected species.***

Many ocean fisheries are undergoing rapid change, some due to natural variability and others due to human activities – over-fishing, the destruction and polluting of coastal habitats, climate changes resulting from greenhouse gases. While these issues are complex, in many cases it is clear that heavy fishing pressures, both recreational and commercial, are the primary cause. The main objectives of Theme 2 are to enhance our understanding of fisheries dynamics so as to foster better fisheries management, and to provide educational opportunities in this area of research.

CIMAS has a long history of research that focuses on applications of prediction models to specific fisheries. Recently emphasis has shifted to the development and use of risk assessment methods that take into account the role of uncertainty in our understanding of ecosystem and fishery dynamics and the impact of uncertainty in the management process.

The current emphasis on rational management of fishery resources is coincident with an increasing demand for these resources, often in the face of declining fish catches. Emphasis is also placed on proper management of marine protected species. Analysis has shown that there are fundamental constraints on our knowledge of fisheries systems in the context of marine ecosystems. In particular, theoretical models are mostly based on hypothesized relationships among the various components of marine ecosystems, including exploitation by humans. Most models are still in the development stage and they have limited ability as forecasting tools.

Many activities related to this theme are carried out in a sub-unit in CIMAS, the Cooperative Unit for Fisheries Education and Research (CUFER). CUFER was established in 1992 in response to a need for the development of methods for improved quantitative assessment of fish populations and as a source of advice for resource sustainability. CUFER offers the opportunity to work on research issues with long-time horizons, an advantage afforded by academic research. An important ancillary component of CUFER is to develop the human resources and expertise needed for the future research and management of Florida and Caribbean fishery resources. However, the results from this program are broadly applicable to tropical and subtropical fisheries all over the world.

Another fisheries-related unit housed in CIMAS is the Center for Independent Experts (CIE) established in 1998. The primary function of CIE is to organize and facilitate independent peer reviews of stock assessments carried out by the National Marine Fisheries Service (NMFS). Under this program, CIE arranges for the solicitation and selection of qualified scientists who carry out reviews of ongoing and completed assessments and who serve as independent experts on advisory panels and working groups.

Theme 2 activities contribute to NOAA Mission Goal 1: Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management.

Research in this theme is consistent with three Mission Strategies as related to fisheries research:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Understand and describe how natural systems work together through investigation and interpretation of information.*
- *Assess and predict the changes of natural systems, and provide information about the future.*
- *Manage coastal and ocean resources to optimize benefits to the environment, the economy, and public safety.*

Theme 3: Regional Coastal Ecosystem Processes

- ***Carry out research on the ecological health of coastal ocean ecosystems in the Southeast U.S so as to lead to better management strategies.***

South Florida is beset with a broad range of environmental problems that are the result of many decades of intense development in this fragile subtropical environment, unique in the continental United States. Because of the unique character of the region and the widely-diverse and closely-linked terrestrial and aquatic ecosystems, new strategies are required to address these issues. To this end Theme 3 focuses on the development of a scientific framework that links the multitude of special problems and scientific studies across the region.

A major part of the research in Theme 3 is carried out in the context of the South Florida Ecosystem Restoration initiative, a program that seeks to reverse the damage caused by the rapid growth in this region. Legislation passed by Congress several years ago allocates over eight billion dollars for this effort which will take place over several decades. CIMAS and NOAA's Miami laboratories are playing a central role in this program. Research activities under Theme 3 include:

- *Observations and analyses of atmospheric and ocean chemical and physical variability and their impact upon the health of the regional coastal ocean.*
- *Observations and modeling to elucidate how indigenous biological populations and communities respond to the unique physical and chemical environment of South Florida.* How does variability in the environment influence the viability and distribution of biological populations? How is the system changing? What changes (and what consequences) might we expect in the future as the restoration program is implemented?
- *Special integrated studies of critically-stressed or keystone components of the South Florida coastal ecosystem.* These include studies that characterize natural and anthropogenic stressors, that identify causal mechanisms, and that establish ecological endpoints as well as the measurable indicators of progress towards achieving regional coastal ecosystem health.
- *Development of theories and methodologies necessary to understand the biological, ecological and oceanic variables controlling and regulating South Florida coastal fisheries populations, their food sources and their habitat.* We need such knowledge in order to predict variability in space and time with an accuracy useful for management purposes. Fishery problems are an important subset of the coastal ocean ecosystem processes because of their large economic significance both commercially and recreationally in South Florida.

The activities under Theme 3 bring together local management expertise and experience so as to provide analytical tools - models and techniques - for making timely and informed assessments of the combined effects of natural processes and restoration-related actions upon the regional coastal ecosystem. Such tools are essential for the informed management of regional coastal ecosystem resources.

Theme 3 activities contribute to NOAA Mission Goal 1: Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management. They also contribute to Mission Goal 3: Serve society's needs for ... water information.

Research in this theme is consistent with three Mission Strategies as related to coastal ocean processes and their impact on fisheries and other aspects of the coastal environment.

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Understand and describe how natural systems work together through investigation and interpretation of information.*
- *Assess and predict the changes of natural systems, and provide information about the future.*
- *Manage coastal and ocean resources to optimize benefits to the environment, the economy, and public safety.*
- *Study how humans interact with the environment so as to lead to better policy making.*

Theme 4: Human Interactions with the Environment

- ***Study how humans interact with the environment so as to lead to better policy making.***

Theme 4 highlights the role of human systems in environmental decision making. Humans interact with the environment in many ways. Studies of these interactions range from assessing societal risks from natural hazards to considering how population growth and land use changes may affect the health of ecosystems. Humans shape natural systems and are shaped by them. Examples are climate change, the utilization of marine resources, and the urbanization of coastal regions. The inter-dependence of humans and ecosystems makes human interactions a topic of interest to environmental managers as well as to stakeholders and the scientific community.

Researchers use ***integrated assessments*** to study and resolve the complex dynamics of overlapping human and natural systems. This approach goes beyond synthesizing and advancing what is known about a problem - it also ensures that the results are relevant to society. Estuaries, to take one example, are considered as integrated systems. While often thought of as natural systems in terms of their rates of soil and water movement and rich habitats, estuaries are also appropriately regarded as socio-economic systems in terms of the size and distribution of costs and the benefits they help create. It is the interplay of natural and human systems that creates problems for resource managers and opportunities for stakeholders.

There are three distinct foci in ***Theme 4:***

- ***Human dimensions of climate change and variability.***

Researchers seek to improve our understanding of how social and economic systems are currently influenced by climatic fluctuations, and how human behavior can be affected by using our gained knowledge about variability in the climate system, for example, by using El Niño forecasts in agriculture.

- ***Sustainable use of the world's fisheries.***

Researchers emphasize the role of human behavior in the fisheries and marine ecosystems to be managed.

- ***Urbanization of the Coastal Zone.***

Half the nation's population lives on coastal lands which comprise only 17% of the total land area. Recent assessments of coastal zone impacts identify the dominant ecological risks as habitat alteration, hydrological alteration, and the over-exploitation of natural resources. Research under Theme 4 facilitates this dialog and leads to the development of new analytical tools with which to identify problems, to characterize sources of environmental degradation, and to monitor progress towards restoration.

Theme 4 activities contribute to NOAA Mission Goal 1: Protect, restore and manage the use of coastal and ocean resources through ecosystem-based management. Also, Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond.

Research in this theme is consistent with all five Mission Strategies as related to the human dimensions of environmental change:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Understand and describe how natural systems work together through investigation and interpretation of information.*
- *Assess and predict the changes of natural systems, and provide information about the future.*
- *Engage, advise, and inform individuals, partners, communities, and industries to facilitate information flow, assure coordination and cooperation, and provide assistance in the use, evaluation, and application of information.*
- *Manage coastal and ocean resources to optimize benefits to the environment, the economy, and public safety.*

Theme 5: Air-Sea Interactions and Exchanges

- ***Understand the energy exchanges and interactions between the atmosphere and the oceans and the consequent effects on atmospheric and ocean mixing and circulation.***

The oceans are an important source of the energy that drives large-scale atmospheric circulations; conversely, the wind systems drive oceanic mixing and circulation. The interplay between the ocean and the atmosphere can result in large variations in global weather patterns as demonstrated by the impact of el Niño events. These interactions involve a wide range of properties such as the air and sea-surface temperatures, humidity, wind speed, rainfall, salinity, mixed-layer depth and heat content. The ocean plays a major role in the biogeochemical cycles of many important species that can have an important role in climate forcing: e.g., CO₂, halocarbons, aerosols. Air-sea exchange processes control the amount of these materials that remain in the atmosphere and thus the degree to which these species, both natural and pollutant, can affect radiative processes and climate.

Research on air-sea interactions largely focuses on processes in the marine atmospheric boundary layer and the surface waters of the ocean including the oceanic mixed layer and the top of the seasonal thermocline. It also extends into maritime cloud climatology and to maritime weather system prediction - from coastal fog and stratus clouds to tropical waves, squall lines and hurricanes.

An equally important area of research focuses on the exchange and interaction between the atmospheric environment of the coastal urban complex and the coastal marine atmosphere; the deposition of pollutants to coastal waters are known to have a substantial impact on coastal ecosystems. The ultimate objective of these various programs is to develop and verify physical-chemical models of the atmosphere and the ocean and the processes that couple them. Another critical area of research is to understand the role of the upper ocean on hurricane intensity changes.

RSMAS has developed a strong program in air-sea interaction studies. University scientists work closely with AOML in research on in situ exchange processes and in the development of new instrumentation such as airborne oceanography. Remote sensing techniques are playing an increasing role in studies of the marine boundary layer and the upper ocean including the interface. Both RSMAS and AOML work closely together in these areas.

Theme 5 activities contribute to NOAA Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond.

Research in this theme is consistent with two Mission Strategies:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Assess and predict the changes of natural systems, and provide information about the future.*

Theme 6: Integrated Ocean Observations

- ***Study the integration of modeling and physical measurements in the ocean and the atmosphere so as to achieve optimal designs of observing systems.***

Observing systems are costly to design, to deploy, and to maintain. To design an efficient system it is necessary to first identify the critical variables to be measured, the spatial configuration of sensors, and the frequency of measurements necessary to identify and characterize temporal and spatial trends. Consequently the development of integrated observing systems requires the interplay of numerical models and observing system networks so as to accurately and efficiently estimate the optimal fields of essential oceanic variables. Another objective of this research is to develop the criteria for the acquisition of oceanic data needed to determine and document the role of the ocean in long-term climate change and to monitor these changes.

The optimal system must accomplish several objectives. It must efficiently characterize climate variability and change in the presence of geophysical noise; it must provide a product that can support marine ecosystem management with physical transport estimates; and it must provide initialization, validation, and verification data for climate forecast models. The design of ocean observing systems depends on the scale of the domain, the processes of interest, and the application of the data that is to be obtained. For example, on global scales systems must be designed to observe climate variability and dynamics. Regional scales must be observed for marine resource management, waterborne pollution mitigation, and efficient navigation. Coastal scales must be observed to support marine ecosystem management, pollution response, safe navigation, and coastal flooding.

Careful design studies are needed to determine the optimal mix of *in situ* (Eulerian and Lagrangian) sensors, satellites, and other remote sensing observations. Observational evidence indicates that the coupled air-sea system is undergoing dramatic changes on long time scales - for example, the melting of the Arctic and Greenland ice caps, the increasing surface temperatures. These changes will have a great impact on transport and mixing in the Atlantic. CIMAS investigators have a long history of tracking Atlantic thermohaline circulation, a major factor in climate variability over longer periods. We currently lack a good understanding of the time-scales of the factors that control Atlantic circulation. This will require continued observations in the Atlantic coupled with numerical modeling.

Theme 6 activities contribute to NOAA Mission Goal 2: Understand climate variability and change to enhance society's ability to plan and respond. Also, Mission Goal 4: Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation.

Research in this theme is consistent with three Mission Strategies:

- *Monitor and observe the land, sea, atmosphere, and space and create a data collection network to track Earth's changing systems.*
- *Understand and describe how natural systems work together through investigation and interpretation of information.*
- *Assess and predict the changes of natural systems, and provide information about the future.*

RESEARCH ACCOMPLISHMENTS AND HIGHLIGHTS

Theme 1: Climate Variability

Investigating the Impact of the Saharan Air Layer on Tropical Cyclone Intensity Change

J. Dunion (UM/CIMAS); J. Prospero (UM/RSMAS); S. Aberson, W. Barry, M. Black, N. Dorst, S. Feuer, J. Kaplan, C. Landsea, P. Leighton, F. Marks, M. Powell and R. Rogers (NOAA/HRD); J. Hawkins (NRL/Monterey); C. Velden (UW/CIMSS)

Outbreaks of hot, dry, dusty African air masses can have a great impact on the meteorology of the tropical Atlantic including the suppression of tropical storms and hurricanes. Research efforts focused on improving our ability to study the interaction of these African air masses with tropical cyclones. We have developed new techniques to track these events with satellites. We have refined our understanding of the climatology of the tropics and we continue to develop strategies for sampling these Saharan air masses and their impact on tropical cyclones using hurricane reconnaissance aircraft. These efforts all have the potential to further our understanding of tropical cyclones intensity change and general tropical climate processes.

Studies of Climate Feedbacks and Sensitivity Using GFDL Models

B.J. Soden (UM/RSMAS); I.M. Held (NOAA/GFDL)

In an effort to assess climate-forcing sensitivities, we investigated the climate feedbacks in coupled ocean-atmosphere models using a coordinated set of 21st century climate change experiments. Water vapor is found to provide the largest positive feedback in all models. The feedbacks from clouds and surface albedo are also found to be positive in all models, while the only stabilizing (negative) feedback comes from the temperature response. Large intermodel differences in the lapse-rate feedback are observed and shown to be associated with differing regional patterns of surface warming. Intermodel differences in cloud feedback are found to be a factor of 4 larger than for other feedbacks and provide the largest source of uncertainty in current model predictions of climate change due to increasing greenhouse gases.

Assessment of Decadal Variability in the Tropical Radiation Budget

B.J. Soden and A.C. Clement (UM/RSMAS); A.J. Broccoli (Rutgers Univ.)

Satellite observations over the period 1984-2001 indicate a trend of decreasing shortwave reflection which no General Circulation Model can currently reproduce. A series of model sensitivity experiments and an empirical analysis of satellite observations suggest that the tropical-mean radiation budget is remarkably insensitive to changes in the tropical circulation. In contrast, rather small changes in a model's convective precipitation efficiency can generate changes comparable to those observed. The true sensitivity of the real climate system to changes in precipitation efficiency remains highly uncertain due to the lack of observational and theoretical constraints on cloud microphysical processes. This research emphasizes the critical need for specific types of measurements to address these issues.

A Radiance-Based Analysis of Satellite and Radiosonde Records to Document Long-Term Water Vapor Changes

B.J. Soden (UM/RSMAS); D.L. Jackson (NOAA/CIRES); X. Huang (Princeton Univ.)

Atmospheric water vapor plays a critical role in climate forcing. Climate models predict that the concentration of water vapor in the upper troposphere could double by the end of the century due to increases in greenhouse gases. This moistening plays a key role in amplifying the rate at which the climate warms in response to anthropogenic activities. In this study satellite measurements were used to identify a distinct radiative signature of upper tropospheric moistening over the period 1982-2004. The observed global moistening corresponds approximately to a constant relative humidity increase in upper tropospheric water vapor and is accurately captured by climate model simulations. These results provide a critical test of our understanding of water vapor changes in the climate system and lend further credence to model projections of future global warming.

Processes that affect the annual and inter-annual variations of the Western Hemisphere Warm Pool (WHWP)

S.-K. Lee (UM/CIMAS); D. Enfield, C. Wang and C. Landsea (NOAA/AOML)

Climate over a large area of the United States is impacted by the large pools of warm water (water warmer than 27.5°C) in the eastern North Pacific, the Gulf of Mexico and the Caribbean Sea. Our research shows that this warm pool is an important source of moisture for the surrounding land masses and that the size of the warm pool undergoes large interannual fluctuations that influence rainfall and the frequency of hurricanes. We now think we understand most of the conditions that lead to very large warm pools. We are now using an ocean model to realistically simulate the warm pool variability. The eventual goal of the research is to predict warm pool variations and their climatic impacts where people live.

Moisture Budget in the Intra-Americas Sea, its Transport into North America and their Roles in Warm-Season Precipitation

A.M. Mestas-Núñez (UM/CIMAS); C. Zhang and B.A. Albrecht (UM/RSMAS); D.B. Enfield (NOAA/AOML).

The warm pool of the Intra-Americas Sea (IAS, i.e. Gulf of Mexico and Caribbean Sea) plays a major role as a source of moisture for North America warm-season precipitation. In order to understand climate variability in this region, we must be able to estimate the moisture balance – that is, the relative amounts of evaporation, precipitation, and the net moisture fluxes through the region lateral boundaries. We used atmospheric observations and model analyses in and around the IAS to calculate the moisture balance and its variability. We found significant associations with the Pacific North American and El Niño-Southern Oscillation climatic modes. These had an impact on precipitation in central US.

CO₂/CLIVAR Repeat Hydrography Program CO₂ Synthesis Science Team

F.J. Millero (UM/RSMAS); R. Wanninkhof and T.-H. Peng (NOAA/AOML); R. Feely and C.L. Sabine (NOAA/PMEL); R. Key (Princeton); A. Dickson (Scripps); A. Kozyr (ORNL/CDIAC)

In order to better understand the various factors affecting the global carbon cycle and the role of the oceans in the global inventory of CO₂ we need a globally consistent data set of ocean parameters. To this end, the CO₂ Synthesis Group is critically examining the more recent oceanic data prior to incorporating these data into a global database. These data are being made available through a series of papers and reports and through databases accessible to the broader community. This work has resulted in a markedly improved picture of the global ocean carbon cycle.

A Study on the MJO-ENSO Problem

C. Zhang (UM/RSMAS)

The Madden-Julian Oscillation (MJO) has been observed to significantly influence predictions made with El Nino-Southern Oscillation (ENSO) models. In order to evaluate and understand the possible influence of the MJO on the ENSO cycle we have analyzed the effect of different MJO estimates derived from observations on several ENSO models. We found that the MJO estimates derived from observations can have a large impact on the tropical Pacific coupled system. This suggests that improving our capabilities to forecast the level of MJO activity will result in an increase in our ability to forecast ENSO.

Gulf Stream Re-Analysis: Structure, Transport, and Dynamics

R. Garcia (UM/CIMAS); L. Beal (UM/RSMAS); C. Meinen (NOAA/AOML)

The Gulf Stream carries warm water far to the north in the Atlantic, producing significant effects on both global and regional climate. This project is producing a more accurate and complete description of the Gulf Stream transport and structure which will lead to better climate modeling when this is used to initialize the models. We combined data from a large number of different mooring types to produce detailed mean cross-sections of the Gulf Stream. We find the transport is slightly higher than had been previously thought, and the difference in transport is evenly spread throughout the water column.

Theme 2: Fisheries Dynamics

Modeling connections between life stages and habitats of pink shrimp in South Florida

M. Ciales and J. Wang (UM/RSMAS); J.A. Browder and T. Jackson (NOAA/SESFC); M. Robblee (USGS/CWRS)

Pink shrimp was selected as indicator species of the NOAA-South Florida Ecosystem Restoration Prediction and Modeling (SFERPM) to evaluate the impact of upstream water management changes in Florida Bay. To assess the impact of water hydrographic properties on populations, we developed a Lagrangian trajectory model which includes larval behaviors. Model results show that the mechanism used by planktonic stages to reach the nursery grounds across the SW Florida shelf is strongly dependent on tidal currents and the larvae's ability to select the appropriate tidal current during their journey. The annual current cycle is consistent with the observed summer peak in post larvae suggesting that this species and other coastal fishes and invertebrates may take advantage of this tidal cycle to increase their chance of successfully reaching coastal habitats.

Monitoring Coral Reef Fish Utilization of MPAs and Recruitment Connectivity between the Florida Keys and Meso-American Reefs

M.R. Lara and D.L. Jones (UM/CIMAS); J.T. Lamkin (NOAA/SEFSC)

The abundance of many reef fish in the Florida coral reef ecosystem is dependent on many variables including the transport of fish larvae from distant sources. This information is crucial to the management of fishes both in Florida and the Dry Tortugas and to the local artisanal fisheries supported in the Yucatan. Research cruises found an outstandingly high abundance of bonefish larvae in the spring of 2004 and again in March 2005. Bonefish are an important recreational fishery in South Florida. Thus management strategies must take into account the possible importance of recruitment from waters off Yucatan.

Monitoring Coral Reef Fish Utilization of MPA's and Inshore Habitats in Florida Bay

M.R. Lara and D.L. Jones (UM/CIMAS); J.T. Lamkin (NOAA/SEFSC)

In order to protect juvenile reef-fish habitats, we must be able to identify them on a species basis. We have developed techniques which enable us to identify the nursery habitat of a fish. This procedure is based on the measurement of trace elements, including rare earths, in the otoliths (ear bones) of fishes. This is the first study to use rare earth elements as a tracer in otoliths. This study can be used to understand patterns of habitat use of important fishes such as the gray snapper.

Settlement, Growth, and Migration of Snappers in Florida Bay and Adjacent Marine Ecosystems

M. Lara and D. Jones (UM/CIMAS); T.L. Gerard (NOAA/SEFSC)

In order to successfully manage fisheries, we need information of every stage of the life cycle of individual species so that critical habitats can be identified and assessed for possible impacts that might result from the alteration of these areas. We explored the spatial and temporal variability of otolith chemistry in juvenile gray snapper within the Florida Bay and surrounding marine regions in South Florida by measuring stable isotopes of carbon and oxygen in the otoliths (earbones) of these fish. We find that the stable isotope ratios of carbon and oxygen allows us to identify the regions occupied by fish during their lives. Our studies of the otoliths of gray snapper have been particularly successful in characterizing differences in ambient and metabolic environmental conditions experienced throughout their life history.

Effort Response, Harvest, the Economy, and Climate in the Gulf of Mexico Recreational Fishery

D. Letson (UM/RSMAS); D.W. Carter (NOAA/SEFSC)

Effective evaluation of fisheries rebuilding plans requires information on how policies will affect recreational fishing effort and harvest. This information helps to forecast the economic effects of policy changes and improves fishery management. However, there is little research on the extent to which variations in climate events and overall economic activity can influence the outcome of policy changes. We examine this issue using econometric models and data from the Gulf of Mexico head boat red snapper fishery. Our results suggest that climate and weather phenomena such as El Nino and hurricanes can dramatically influence the potential effects of bag limits, size limits, and closed seasons.

Abundance and Diel Migrations of Demersal Mesozooplankton and Small Reef Fishes and their Trophodynamic Contribution to the Coral Reef Ecosystem

S. Smith, J. Luo, P. Lane and D. Pilz (UM/RSMAS); P.B. Ortner, J.C. Hendee, S. Cummings and J. Stamates (NOAA/AOML); J. Lamkin and D. Jones (NOAA/NMFS)

It is essential to study of coral reef ecosystems so as to establish a baseline of their present health and ecology and to gain a better understanding of the intricate processes that determine the responses of reef communities to environmental perturbations, whether natural or man-induced. The present study focused on the bio-physical relationships and processes that control and impact planktonic processes in a coral reef ecosystem in St. Croix. A variety of autonomous acoustic and optical sensors were deployed in close proximity to a NOAA Coral Reef Early Warning System (CREWS) to study zooplankton population dynamics in relation to local environmental processes (e.g., current, temperature and light fluctuations). The local current regime and the migratory behavior of some zooplankton species appear to interact to modify the plankton community over the reef on a daily basis. These results suggest that the reef ecology and health is highly dependent upon upstream ecosystem dynamics.

Pelagic Longline Sea Turtle Mitigation Research: Hook and Bait Feeding Trials

L. Stokes, and M. Burgos (UM/CIMAS); S. Epperly, J. Watson, D. Hataway, C. Bergmann, L. Belskis, B. Higgins, D. Foster, J. Gearhart, and L. Saxon (NOAA/SEFSC)

The by-catch of sea turtles, an endangered species, is a serious problem in longline fisheries. We conducted research to evaluate sea turtle interactions with baited hooks in an effort to reduce their incidental capture and mortality in pelagic longline fishing gear. Our goal was to develop methods to further protect these endangered and threatened species. Feeding tests in this study showed that sea turtles were less likely to fully ingest larger hooks than smaller hooks and they were less likely to fully ingest hooks baited with sardines than those baited with squid. These data can be used to strengthen the mitigation measures recently enacted to reduce incidental capture of sea turtles.

Mapping Effort and Harvest in Puerto Rico's Recreational Fishery

H. Stone (UM/CIMAS); D.W. Carter and B. Gentner (NOAA/SEFSC)

The evaluation of fishery management policies such as marine protected areas requires information about the spatial distribution of fishing effort and harvest. This information is useful in identifying concentrations of fishing pressure and in calculating the cost of closing areas to fishing. To examine this issue, we created maps from a survey about the location of recreational fishing and harvest around Puerto Rico. The maps can help fishery managers and stakeholders understand the potential displacement in fishing effort associated with proposed marine protected areas.

Theme 3: Regional Coastal Ecosystem Processes

Regional Model for South Florida Coastal Seas

V. Kourafalou (UM/RSMAS); G. Goni (NOAA/AOML)

In order to resolve issues about water quality in Florida coastal waters and in Florida Bay, we need to be able to quantitatively link these waters to the larger scale circulations in the region. To this end we have developed for the first time a comprehensive regional transport and circulation model that encompasses the Straits of Florida and the southwest Florida shelf. Our model, SoFLA-HYCOM, is the South Florida adaptation of the community-based Hybrid Coordinate Ocean Model (HYCOM) and it is nested within a larger scale HYCOM model. The SoFLA-HYCOM is an important development for South Florida ecosystem research, as it includes ecologically sensitive areas, such as the Dry Tortugas, Florida Bay and the Florida Keys and is suitable (through proper coupling and nesting) for the study of the interactions between physical and biogeochemical processes and between coastal and oceanic processes. When coupled to biochemical models, the SoFLA-HYCOM provides support to biological and water quality studies within Florida Bay.

Long-Term Measurement of Physical, Chemical, and Biological Water Column Properties in the South Florida Coastal Ecosystem

C. Kelble, G. Rawson, N. Melo and B. Kates (UM/CIMAS); T. N. Lee, (UM/RSMAS); P. Ortner, L. Johns, R. Smith and J.-Z. Zhang (NOAA/AOML); C. Hu (USF)

It is vitally important to understand the factors that affect the circulation and water property patterns of Florida Bay and surrounding waters because this area will most likely be significantly impacted in the coming years as a result of the Comprehensive Everglades Restoration Plan (CERP) which will substantially restore the natural water flow patterns. To this end we conduct monthly small scale cruises, bi-monthly large scale cruises in the surrounding coastal waters, and maintain a moored instrument array to continuously monitor currents and water property characteristics at select sites. From these data we have determined the baseline circulation and water property patterns and we can now monitor how these characteristics change. We have been able to associate large-scale changes with various factors including singular climactic events, such as *El Niño* and tropical cyclones, most notably in 2004 in association with the passage of Hurricane Irene which produced the lowest salinity patterns of the year. This work demonstrates how tropical cyclones can play a dramatic role in effecting changes in the South Florida ecosystem.

Real-time Currents and Water Quality Monitoring in the Florida Keys National Marine Sanctuary (FKNMS)

N. Melo, C. Kelble, H. Guarin, B. Kates and G. Rawson (UM/CIMAS); T.N. Lee (UM/RSMAS); E. Johns, P.B. Ortner, J.C. Hendee, R. Smith, S. Cummings, D. Bitterman and U. Rivero (NOAA/AOML); C. Hu (Univ. S. Florida)

The water quality in FKNMS is strongly dependent on the complex interplay of currents and the exchanges with surrounding waters. Our study focuses on the passages between the Florida Keys. The flows through these passages control exchanges with Florida Bay and the southwest Florida shelf; these flows can have a strong impact on the coral reef tracts of the FKNMS. Results from studies conducted at Long Key Channel and the Seven-Mile Bridge show that currents in the passages are strongly driven by local wind forcing and gravity driven transports produced by cross-key sea level differences on time scales of several days to weeks. This research will

potentially lead to an automated, real-time method for monitoring the flows through the passages from the Bay to the reef and vice versa, and will provide increased scientific understanding to assist in ecosystem-based resource management of the FKNMS.

Determination of Genetically Distinct Subgroups and Contaminant Body Burdens of Resident Bottlenose Dolphin (*Tursiops truncatus*) within Biscayne Bay, FL

J. Litz, M. Gaines and J. Wicker (UM/CIMAS); L. Fieber and P. Walsh (UM/RSMAS); L. Garrison, J. Kucklick, P. Rosel, A. Martinez and J. Contillo (NOAA/SEFSC); C. Hughes (Florida Atlantic University)

Some areas of Biscayne Bay are substantially impacted by pollutants carried in runoff from coastal urban and agricultural areas. Bottlenose dolphins (*Tursiops truncatus*) are long-term residents in Biscayne Bay and are vulnerable to bioaccumulation of persistent organic pollutants (POPs). In this study we define the genetic structure of the resident bottlenose dolphin population in Biscayne Bay and measure POPs in their blubber. The variance in POP concentrations between samples is largely explained by geographic location within Biscayne Bay. Animals with sighting histories primarily in the northern, more developed, area have higher POP concentrations relative to animals with sighting histories in the southern, less developed, area. This most likely indicates that the differences are a result of the habitat occupied by the dolphins and the POP concentrations in their prey.

Simulation and Analysis of Monthly Salinity Patterns Resulting from Alternative Configurations of the Southern Golden Gate Estates Restoration Project

J.D. Wang (UM/RSMAS); J. Browder (NOAA/SEFSC)

A wide variety of water flow schemes are being considered under the South Florida-Everglades Restoration plan. In our program we use a hydrological model to predict the effects of various proposed hydrologic restoration schemes on the salinity and fish abundance in Faka Union Bay, an important estuarine ecosystem supporting juvenile fishes on the southwest Florida coast. Our model predicts the greatest gains in abundance with a return to the “natural system” condition and with the restoration design alternative that most closely mimics the freshwater runoff volume and timing of the natural system condition. Our model will serve as a management tool that can provide a range of goals and options for restoration efforts.

Demographic monitoring of *Acropora palmata* in the Florida Keys

D.E. Williams and B. Mason (UM/CIMAS); M.W. Miller (NOAA/SEFSC)

Elkhorn coral (*Acropora palmata*) is one of the dominant framework builders on Florida and Caribbean reefs. Populations of *A. palmata* have declined by more than 90% since the 1980s and it is currently being proposed for listing as ‘threatened’ under the Endangered Species Act. In this study we are documenting the status and distribution of the remaining elkhorn populations in the upper Florida Keys in an effort to determine the relative importance of the various ‘threats’ (disease, predation, storms, etc) to these populations. We find that disease has had the greatest impact on the corals. In spite of the very active 2004 hurricane season, relatively little physical damage resulted from the hurricanes. However, Hurricane Dennis in July 2005 caused widespread fragmentation and most likely exacerbated disease impacts on the population. Approximately 70% of the storm generated fragments were rapidly losing tissue which suggests that asexual recruitment will be minimal.

Theme 4: Human Interactions with the Environment

Assay and Sensor Development to Identify, Detect, and Quantify Microbial Contaminants

I.B. Baums and C. Garcia, (UM/CIMAS); J.W. Fell (UM/RSMAS); K. Goodwin (NOAA/AOML)

Microbial contamination impacts coastal water quality. As the nation's coastal areas become more urbanized, poor water quality has increasingly negative economic, health, and environmental impacts. Proper assessment and understanding of the factors that effect coastal water quality requires the ability to rapidly and simultaneously detect multiple microbial contaminants. We developed a novel molecular approach to detect fecal contaminants in coastal waters using Luminex technology. This new tool will help environmental managers who need quick and accurate measures of water quality so that they can restrict human access to contaminated marine waters.

Technology Transfer: Luminex and Microplate Detection of Microbial Contaminants in Coastal Water

J. Fell (UM/RSMAS); K. Goodwin (NOAA/AOML), M. O'Donovan Dix (RTI - subcontract)

The contamination of rivers and coastal waters with harmful microorganisms is a serious nation-wide problem. Methods are needed that can produce fast, cheap, reliable measures of such contamination. As part of a related CIMAS-AOML program, two DNA hybridization technologies were developed which satisfied many of these requirements. In this present activity we performed a market analysis for these techniques. The market that seemed best suited for the least amount of developmental effort is to adapt the Luminex assay for microbial source tracking.

Electrochemical Biosensors for Improved Protection of Coastal Resources and Public Health

M.J. LaGier and C. Garcia (UM/CIMAS); J. Fell (UM/RSMAS); K. Goodwin (NOAA/AOML)

Coastal waters can be highly impacted by a wide variety of pathogens that can adversely affect aquatic ecosystems, human health and the economy. In order to minimize impacts we need small, rugged, sensitive, and cheap biosensors that would enable us to rapidly detect harmful microorganisms. In our program we use DNA sequences as markers to indicate presence and abundance of harmful species in coastal waters. We are developing marine biosensors to measure DNA via cutting-edge electrochemical detection methods. Our electrochemical technique is being adapted for use in a portable instrument for improved, simultaneous detection of human pathogens and microbial indicators of pollution.

Climate Information System for Agriculture and Water Resources Management in the Southeastern USA: The Southeastern Climate Consortium (SECC)

G.P. Podestá, D. Letson and K. Broad (UM/RSMAS); F. Miralles-Wilhelm, S. Ahmad and R. Garcia (UM/Engineering); J.W. Jones, C.W. Fraise, S. Jagtap, C. Porter and K.T. Ingram (Univ. of Florida, Agricultural and Biological Engineering); P. Hildebrand (Univ. of Florida, School of Natural Resources and the Environment); J.J. O'Brien and D. Zierden (Florida State University); G. Hoogenboom, D. Stooksbury, C. Roncoli and J. Paz (Univ. of Georgia)

Climate variability can be expected to have an impact on agriculture. But it is not clear how the farmer can use climate forecasts to increase farm income. In our program we develop ENSO-based forecasts which are coupled to economic and statistical models which are tailored to specific crops. To benefit society, climate information must enter agricultural decision making processes and affect decisions. We developed whole-farm risk models which aid the farmer in making decisions. Working with agricultural agents, we present these forecasts via the web to the agriculture community in the southeastern US.

Theme 5: Air-Sea Interactions and Exchanges

Air-Sea Flux Estimation in High Wind Boundary Layers; Air-Sea Fluxes in High Winds – Analysis of the CBLAST Data

W. Drennan (UM/RSMAS)

Tropical storms gain their energy primarily from the condensation of water vapor evaporated from the warm ocean waters. These latent heat fluxes are a critical parameter with respect to the development of tropical storms. Accurate fluxes are needed as input parameters to coupled hurricane forecast models. Until now however, there have been no measurements of air-sea fluxes at high wind speeds. During the CBLAST campaign, we carried out the first direct measurements of air-sea fluxes in hurricane conditions. Bulk humidity and momentum transfer coefficients were calculated to 32 m/s, extending the known wind speed range by over 50%. These data will lead to improved storm forecasts.

Targeting Strategies to Improve Hurricane Track Forecasts

S.J. Majumdar (UM/RSMAS); S.D. Aberson and P. Leighton (NOAA/AOML/HRD); B.J. Etherton (UNC/Charlotte). Z. Toth (EMC/NCEP).

The forecast of hurricane tracks and intensity is difficult but vitally important. This research focuses on developing improved track and intensity forecasts by optimizing the coverage of dropwindsonde observations released by the NOAA G-IV aircraft - that is, by placing the dropsondes in the regions that will provide the most useful forecast data. We have developed a new model routine which has provided real-time guidance on a regular basis during the 2004 and 2005 hurricane seasons. Results from the 2004 season demonstrate that aircraft observations collected in target areas deemed useful by the model produced marked improvements in operational hurricane track forecasts.

Understanding and Improving the Ensemble Transform Kalman Filter Targeting Strategy

S.J. Majumdar (UM/RSMAS); S.D. Aberson (NOAA/AOML/HRD); C.H. Bishop (NRL/Monterey)

A major NOAA objective is to improve 3-7 day forecasts of precipitation over North America. One method of making such improvements is by augmenting the routine observational network with extra upstream observations. The goal of this research is to evaluate and further develop an adaptive observing strategy to quantitatively predict how observations will affect forecasts with the intention of improving the targeting of observations. The influence of observations on operational forecasts was analyzed via data denial experiments - that is, experiments in which observational data are selectively withheld from the data assimilation. Our results

are encouraging. Preliminary results show that the influence of dropwindsondes deployed over the NE Pacific in winter 2005 reached eastern N. America in 3-4 days, and Europe in 6-7 days. We expect that the application of this model will lead to improved forecasts.

Drag Coefficient Distribution and Wind Speed Dependence in Tropical Cyclones

N. Morisseau-Leroy and R. St. Fleur (UM/CIMAS); M. Powell (NOAA/AOML)

This project will update the most recent measurements of surface drag coefficient (C_d) in hurricanes to extend the measurements to mean boundary layer (MBL) winds over 70 m/s. The improved drag coefficient (C_d) will provide more accurate forecasts of intensity and storm position, which can help prevent over warning and better prepare people for hurricane evacuation. Mean profiles and relationships will be made available to modelers to evaluate existing model surface layer momentum flux packages as well as develop new parameterizations for the coupled H-WRF model. Scientists will use the HRD GPS Dropwindsonde Management Tool to ingest GPS profiles in the database, view, analyze, and quality control the GPS profiles. Once we complete the development of the GDDMT, then scientific and statistical analysis will commence.

Development of the WRF Model for Tropical Cyclone Research and Forecasting

D.S. Nolan (UM/RSMAS); M. Bender (NOAA/GFDL); T. Marchok (NOAA/GFDL); R. Tuleya (NOAA/NCEP)

It is necessary to develop more sophisticated hurricane models so as to improve forecasts of track and intensity. We have used the Weather Research and Forecast Model (WRF) model simulations on the NOAA/GFDL computers to study some of the fundamental inner-core processes in tropical cyclones. This research reveals instabilities that may explain why spiral bands are so ubiquitous in tropical cyclones. Other idealized simulations, with moist convection, have shown that the transition from a weak, cold-core cyclone to a strong, warm-core cyclone can be very rapid, and seems to occur when the mid-level humidity reaches a critical value.

Evaluation of Upper Ocean Mixing Parameterizations

E. Uhlhorn (UM/CIMAS); L.K. Shay and G.R. Halliwell (UM/RSMAS); S.D. Jacob (Univ. Maryland, Baltimore County)

Studies show that hurricane intensity is sensitive to upper ocean heat content variations in the region of the storm, as shown for example in Katrina and Rita. To accurately predict hurricane intensity, models need to incorporate a good ocean mixing scheme and a good depiction of initial conditions; these **must** be complemented by *in situ* profile data (current and shear) in the storm region in order to better forecast the impact of the upper ocean on storm intensity. In our program, we are working to achieve this level of understanding for implementation into predictive coupled atmosphere-ocean models. Our research shows that current models have a systematic bias in the initial model temperature structure which impacts isotherm depths and oceanic heat content as well as levels of turbulence required to cool the upper ocean during hurricane passage. These deficiencies, in turn, significantly impact the amount of heat available to the storm through surface fluxes and, thus, the predictability of storm development.

Evaluation of a New Operational Stepped Frequency Microwave Radiometer (SFMR)

E.W. Uhlhorn (UM/CIMAS); P.G. Black (NOAA/AOML); A.S. Goldstein (NOAA/ MAO/ Aircraft Operations Center)

Accurate hurricane forecasts require a detailed picture of surface wind speeds in the hurricane as it passes over the ocean. We have been testing the performance of an airborne Stepped-Frequency Microwave Radiometer (SFMR) to measure the ocean surface microwave brightness which is related to wind speed. The SFMR provides an accurate description of significant wind radii (that is, the extent of storm force, gale force winds) and maximum winds. The SFMR has been successful in our testing and we are transitioning its use to routine operations. Such information is critical for warning and evacuation planning by emergency managers. The surface winds measured by the SFMR will also be useful to provide data for evaluating a new generation of hurricane forecast models (e.g. HWRF).

Theme 6: Integrated Ocean Observations

Coral Reef Early Warning System (CREWS) Project

J. Absten, L. Florit, M. Jankulak and D. Manzello (UM/RSMAS); J. Hendee, M. Shoemaker and J. Craynock (NOAA/AOML); J. Judas (NOAA Corps); E. Stabenau (NOAA/NRC)

Coral reef ecosystems are in crisis, stressed by environmental changes and human influences. Reefs are crucial to supporting healthy fisheries resources, they are an important source of income for tourism-based economies and they protect coastlines from severe storms and wave action. Research show that increased water temperatures, combined with high light levels and low salinity can cause corals to bleach, a condition that can lead to coral mortality. The Coral Reef Early Warning System (CREWS) project is erecting a series of near real-time remote monitoring stations in Florida, the Bahamas, and the Caribbean. Stations are currently installed at North Norman's Reef near the Island of Exuma, Bahamas, and at Salt River, St. Croix in the U.S. Virgin Islands, with plans for additional stations in the Caribbean and Pacific regions. Scientists and marine park managers can use this information to better preserve and manage these unique natural resources.

The ship based surface pCO₂ Program

K. Sullivan and H. Lueger (RSMAS/CIMAS); R. Wanninkhof (NOAA/ AOML)

Assessing the ultimate fate of fossil fuel carbon is one of the most pressing societal and environmental issues facing us. By determining the uptake of carbon between the ocean and atmosphere we can assess the fraction remaining in the atmosphere contributing to the greenhouse effect, and its effect on acidification on the ocean and associated ecological consequences. To adequately constrain ocean and coupled inverse models, regional fluxes have to be constrained to 0.2 Pg C per year, which is about 3 % of the annual fossil fuel emission. We have successfully reached this goal in select regions through innovative use of automated observation of surface water pCO₂ from ships and buoys along with remote sensing products. The long-term goal is to cover all oceanic regions with quarterly flux maps, in collaboration with national and international partners.

The CLIVAR CO₂ Repeat Hydrography Program

K. Sullivan, C. Fonseca, B. Kates and G. Berberian (UM/CIMAS); C. Langdon (UM/RSMAS); R. Wanninkhof and M. Baringer (NOAA/AOML)

In order to assess the impact of fossil fuel CO₂ on climate, we must be able to make an accurate inventory of the carbon stored in the atmosphere and the oceans. The most robust way to accomplish this goal is by measuring changes in atmospheric and ocean carbon inventories over time so as to quantitatively track the changes in these two reservoirs. While atmospheric changes have been accurately measured for many decades, this has not been possible for the oceans until now. In our program we have been able to accurately quantify the changes in the water column carbon in the Atlantic basin by comparing data from recent cruises with those from WOCE cruises that occupied the same transect lines in the late 80's and early 90's. Our data show large changes in the biogeochemical properties of the upper water column. These increases in inorganic carbon are consistent with the anticipated impact of the anthropogenic carbon source changes and the associated climate change. The surprising aspect of the observations is the large changes in oxygen levels at mid water depths which are attributed to climate change associated with those emissions.



Investigating the Impact of the Saharan Air Layer on Tropical Cyclone Intensity Change

J. Dunion and J. Prospero (UMCIMAS)

S. Aberson, W. Barry, M. Black, N. Dorst, S. Feuer, J. Kaplan,
C. Landsea, P. Leighton, F. Marks, M. Powell and R. Rogers (NOAA/AOML)
J. Hawkins (NRL/Monterey); C. Velden (UW/CIMSS)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To understand how the Saharan Air Layer (SAL) affects Atlantic tropical cyclone (TC) intensity.
- **Strategy:** To develop new satellite products for monitoring the dry, dust air in the SAL; to organize a Saharan Air Layer Experiment (SALEX) that will use NOAA's G-IV high altitude jet to investigate SAL/TC interactions during the 2005 Atlantic hurricane season.

CIMAS Research Theme:

- **Theme 1:** Climate Variability

Link to NOAA Strategic Plan Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.
- **Goal 3:** Serve Society's Needs for Weather and Water Information. (*secondary*)

Research Summary:

Large-scale outbreaks of African air often extend over large areas of the tropical Atlantic during the summer months. These air masses originate from over the Sahara and they appear over the Atlantic as an elevated layer of hot, dry, dust-laden air which are readily visible in satellite imagery. This layer, commonly referred to as the Saharan Air Layer, or SAL, can have a great impact on the meteorology of the region. Our studies show that when the SAL overtakes tropical waves, disturbances, or pre-existing tropical cyclones, it tends to inhibit the growth of the systems. The presence of the SAL complicates the process of making forecasts of tropical cyclone intensity and it may explain, in part, the fact that the Atlantic experiences relatively little tropical cyclone activity compared to the Pacific.

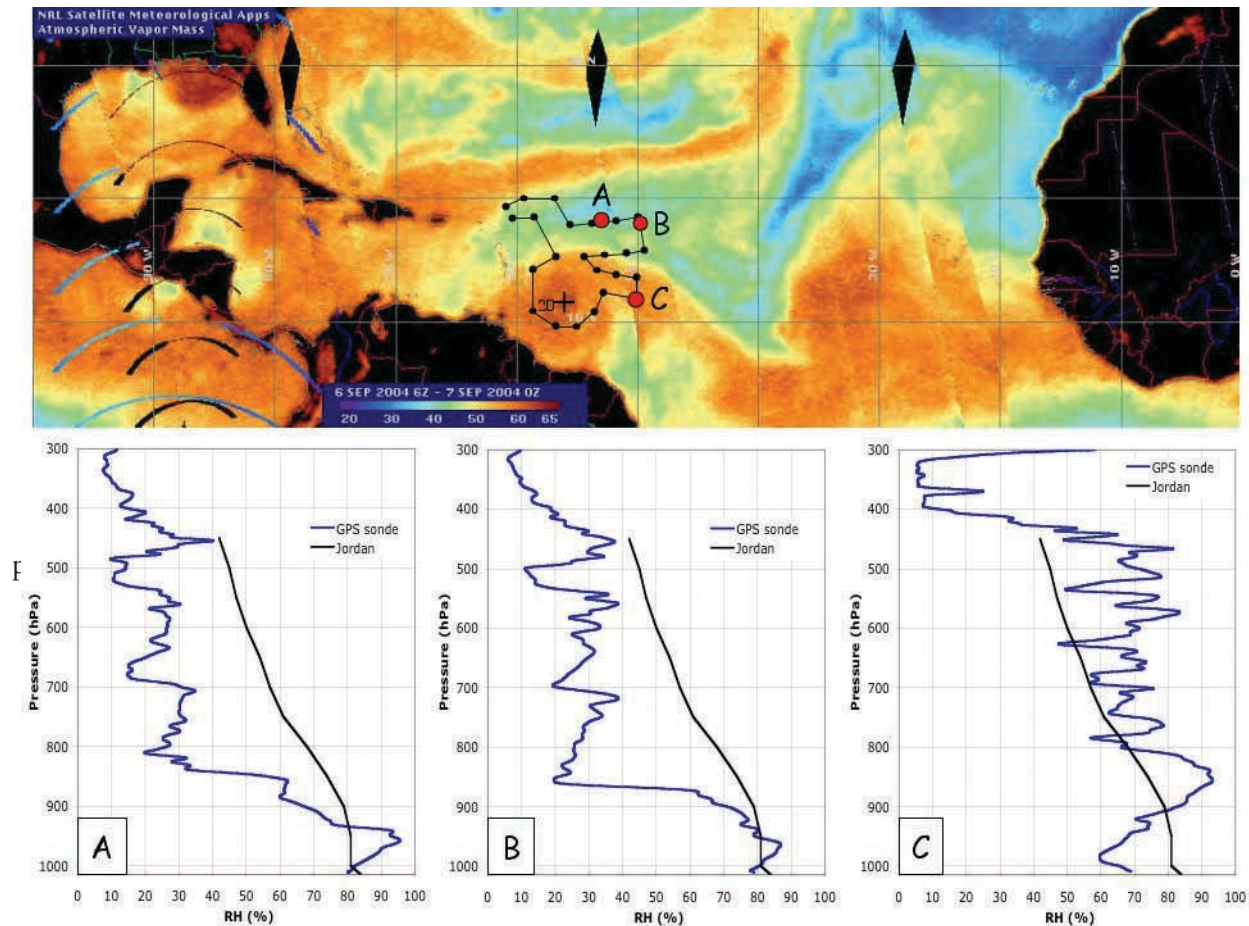


Fig. 1: Satellite mosaic of total precipitable water (TPW) from the constellation of SSSM/I satellites. Blue (orange) shading represents dry (moist) air in the low to middle levels of the atmosphere. Areas to the north and southeast of Hurricane Ivan's center (marked by the "+" symbol) where TPW is <45 mm (blues to greens) are SAL air.

The GOES SAL imagery has previously been used to assess the Jordan mean tropical sounding for the 2001 and 2002 hurricane seasons. This year's efforts have included adding the 1999 and 2000 hurricane seasons to this database. The imagery was used to classify SAL versus non-SAL rawinsondes launched from stations in the Caribbean Sea (~2800 soundings for the four year period) and has indicated that a bimodal distribution of moisture soundings exists in the Caribbean and western North Atlantic. This re-assessment suggests that our understanding of the climatology of moisture in this part of the world needs to be updated.

During a NOAA G-IV hurricane hunter mission around Hurricane Ivan on 06 September 2004, the PI targeted substantial dry SAL air in Ivan's surrounding environment with GPS dropwindsondes. This information was relayed to the National Hurricane Center during the flight and included in that evening's hurricane forecast discussion as a probable reason that the storm was failing to intensify.

We have recently developed new multi-spectral infrared satellite imagery protocols using the GOES-10 and Meteosat-8 satellites to track the position of the SAL. We also developed multi-spectral visible satellite imagery that produces pseudo true color images that are particularly useful for tracking suspended mineral dust in the SAL. As part of the program a SAL Experiment (SALEX) was organized to investigate SAL/Tropical cyclone interactions; 47 research hours were allocated on NOAA's G-IV high altitude jet to carry out these missions during the 2005 Atlantic hurricane season. The main goals of these missions will be to, a) sample

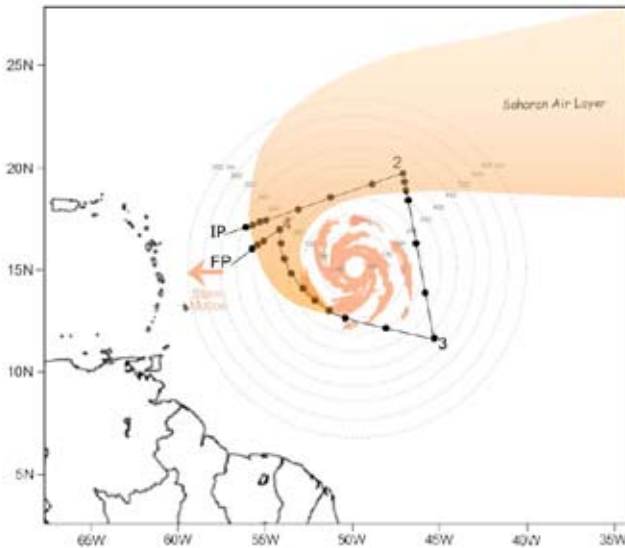


Fig. 2: Sample G-IV flight track for a TC positioned along the southern edge of the SAL.

the high-gradient moisture regions along the SAL's boundaries, b) sample the SAL's mid-level easterly jet along its southern periphery, c) sample intrusions of low humidity SAL air into the TC circulation and observe how the SAL's vertical structure and moisture content modify the TC as the SAL air is advected closer to the TC inner core, and d) send the GPS dropwindsonde data collected during the SALEX missions to NOAA/NCEP for assimilation into the GFS forecast model. The impact of the humidity data (which is not currently assimilated into the GFS) will be assessed as part of a NOAA/ Joint Hurricane Testbed funded project.

Research Performance Measure: All program objectives were accomplished and the overall

Processes that Affect the Annual and Inter-Annual Variations of the Western Hemisphere Warm Pool (WHWP)

S.-K. Lee (UM/CIMAS); D. Enfield, C. Wang and C. Landsea (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To understand which ocean and atmospheric processes are of primary importance for the annual cycle and inter-annual anomalies of the western hemisphere warm pool.
- **Strategy:** To use both data and a model (Hybrid Coordinate Ocean Model: HYCOM) to investigate these processes.

CIMAS Research Theme:

- **Theme 1:** Climate Variability
- **Theme 5:** Air-Sea Interactions and Exchanges (*secondary*)

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

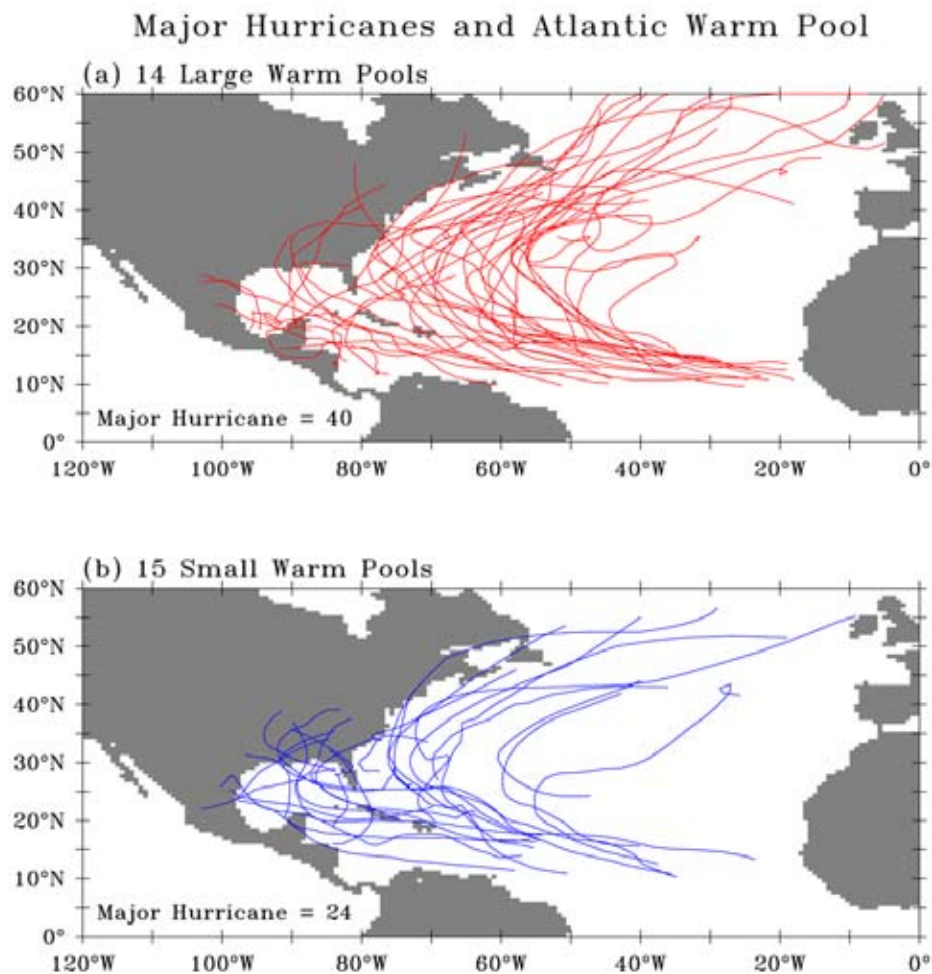
Research Summary:

The Atlantic warm pool (AWP) appears to exert a strong influence on climate over a large region of the US, the Caribbean and South America. Our research seeks to understand this role. The AWP is comprised of water warmer than 28.5°C in the Gulf of Mexico, the Caribbean Sea, and the western tropical North Atlantic (TNA). The size of the AWP reaches its maximum around September. There is considerable variability in the size of the AWP; a large AWP is almost three times larger than a small one. Although ENSO's teleconnections can be an influence on the size of the AWP, about two thirds of the AWP events appear to be unrelated to ENSO. The AWP has an impact on rainfall over the northwest US, Great Plains, the Caribbean, Mexico, the eastern subtropical Atlantic, and the southeast Pacific; and eastern South America. For example, a large AWP and warm TNA are associated with a weakening of the northward surface winds from the AWP to the Great Plains; this hinders the transport of moisture to the Great Plains and leads to decreased rainfall over the region. Conversely small AWP's and a cold TNA correspond to a strengthening of the northward surface winds from the AWP to the Great Plains; this favors moisture transport to the Great Plains and increased rainfall.

On the other hand, large AWP and a warm TNA strengthen the summer regional Hadley circulation that emanates from the warm pool region into the southeast Pacific, changing the subsidence over the southeast Pacific and thus the stratus cloud and drizzle there. Conversely, small AWP and cold TNA weaken the summer regional Hadley circulation that emanates from the warm pool region into the southeast Pacific, changing the subsidence over the southeast Pacific and thus the stratus cloud and drizzle. The large AWP, associated with a decrease in sea level pressure and an increase in atmospheric convection and cloudiness, corresponds to a weak vertical wind shear. Among other effects, these changes are associated with an increase in Atlantic hurricane activity. Figure 1 (next page) shows that there is much more hurricane activity during large warm pools than small ones.

We have also investigated the impact of the large pools of warm water (water warmer than 27.5°C) in the eastern North Pacific, the Gulf of Mexico and the Caribbean Sea: the Western Hemisphere Warm Pool (WHWP). Our research shows that this warm pool is an important source of moisture for the surrounding land masses and that the size of the warm pool undergoes large interannual fluctuations that influence rainfall and the frequency of hurricanes. The heat and moisture budgets of the warm pool have been extensively explored and we now think we understand most of the conditions that lead to very large warm pools, especially the role of wind speed. We are now perfecting the ability of the HYCOM ocean model to simulate the warm pool variability realistically and in the future we hope to model it as a coupled ocean-atmosphere milieu.

Research Performance Measure: The main object is to assess the climate impacts of WHWP. This objective is accomplished.



Data Assimilation with a HYbrid Coordinate Ocean Model (HYCOM)

H.-S. Kang (UM/CIMAS), W.C. Thacker (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To improve simulations of Hybrid Coordinate Ocean Model (HYCOM) by assimilating in-situ and satellite observations such as altimetry, multi-channel sea surface temperature (MCSST), and profile data from ARGO floats.
- **Strategy:** To implement the NRL Coupled Ocean Data Assimilation (NCODA) System which uses a multi-variate optimal interpolation (MVOI) to assimilate in-situ and satellite observations.

CIMAS Research Theme:

- **Theme 1:** Climate Variability

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

The HYCOM model is widely used in ocean-climate modeling. We wish to use the HYCOM model products to feed into the NRL Coupled Ocean Data Assimilation (NCODA) System. Because the NCODA analysis has been done on pressure coordinates, it is necessary to first build an interface to communicate with the model's hybrid vertical coordinate which varies both spatially and temporally to be density-like in the thermocline and below it, pressure-like in the mixed layer, and depth-proportional in shallow water. Our approach has been the following:

- 1) To interpolate HYCOM variables onto z-levels to be used as the first guess in NCODA.
- 2) To get observation-based corrections of variables from the NCODA analysis.
- 3) To put the new variables back into HYCOM layers.

The strategy is to communicate through two existing HYCOM standard files: the archive file and the restart file. The variables communicated between the files are: sea surface height and sea surface temperature from an archive file; temperature, salinity, baroclinic velocities and layer thickness from a restart file. Since density change causes layer displacements, layer thickness must be updated with new density information. This interface is being tested with 1/12 degree horizontal resolution for the Gulf of Mexico.

In Figure 1 we show two cross-sections (with lines showing layer interfaces). The figure compares run 08.7H (Fig 1a) with the control run 01.0H (Fig 1b). Expt_08.7 is the case with daily assimilation and Expt_01.0 is the case of no data assimilation. They have the identical restarting condition on August 10, 1999. After 12 update cycles with the NCODA analyzed variables, temperature and salinity become diffusive in the vertical by mixing warm water down and cold water up. Figure 2 shows the corresponding errors for temperature and salinity between the model and the NCODA analysis. There are maximum temperature errors of about -2.0C and maximum salinity errors of -0.1 ppt. A simple experiment of no data that might change the model's state (skipping the 2nd step above) demonstrates that changing coordinates (back and forth between z-level and hybrid layers without observed data) is very highly diffusive and weakens the stratification at each step. This vertical diffusion caused by interpolation could be counteracted with the assimilated data if there are enough profiles that provide information about the ocean's stratification. However, there are very few such profiles available in the Gulf of Mexico.

This vertical diffusion introduced by interpolation can be avoided if the NCODA analysis is computed in HYCOM's native coordinates. Therefore, we conclude that it is time to convert the NCODA codes to work directly with HYCOM's layers. This conversion will be our task for the coming year.

Research Performance Measure: Our original objective is to improve simulations of HYCOM by assimilating *in-situ* and satellite observations. To accomplish it, the strategy is to implement a mature NRL's Coupled Ocean Data Assimilation (NCODA) system into a HYCOM. As a quick solution, we choose to build an interface between NCODA and HYCOM. Unfortunately, our research shows that this approach will not work and that a new strategy is required.

Gulf of Mexico 1/12° HYCOM Simulation : implementing the NCODA with re-layerization

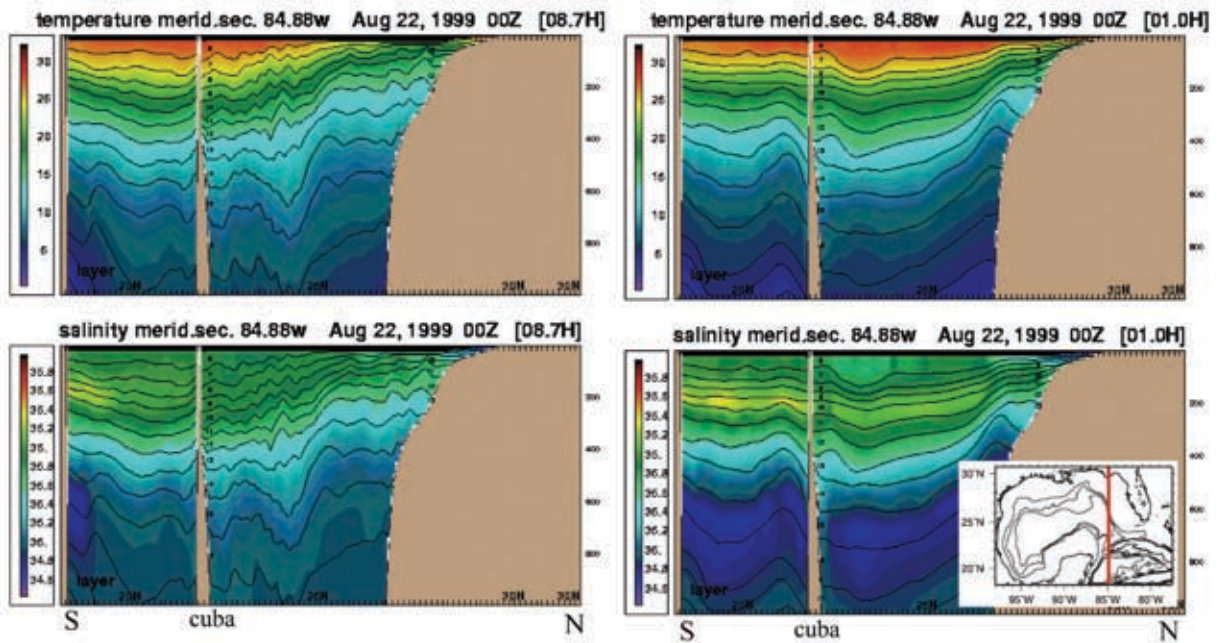


Fig 1a daily data assimilation (expt_08.7)

Fig 1b no data assimilation (expt_01.0)

Fig 1 Temperature (top) and salinity (bottom) transects along 84.88W in the Gulf of Mexico for the Expt_08.7 of daily data assimilation (1a) and the Expt_01.0 of no data assimilation (1b) on August 22, 1999. Lines show layer interfaces.

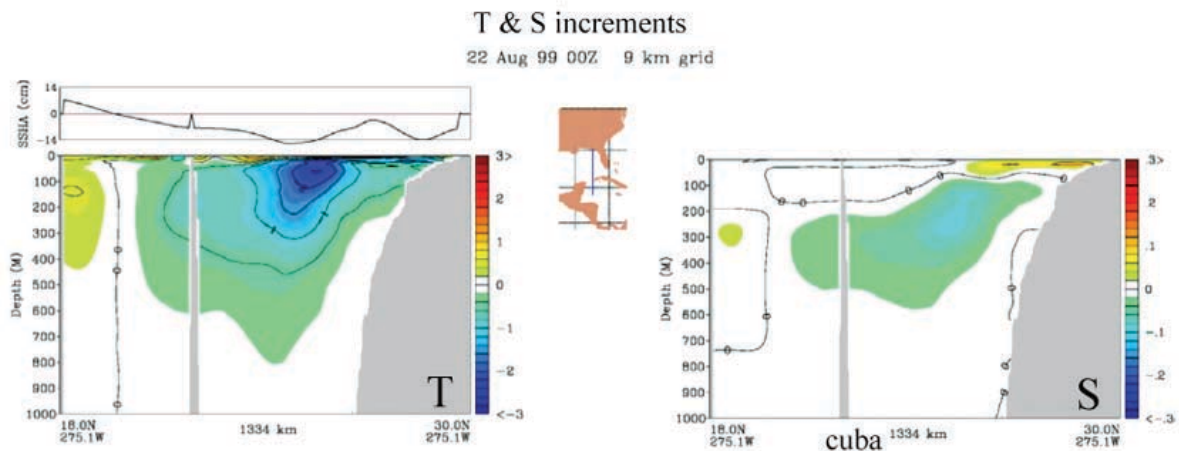


Fig 2 Temperature and salinity errors between the model and the NCODA analysis on August 22, 1999.

Gulf Stream Re-Analysis: Structure, Transport, and Dynamics

R. Garcia (UM/CIMAS); L. Beal (UM/RSMAS); C. Meinen (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To gain a more accurate understanding of the structure and transport of the Gulf Stream and its role in climate.
- **Strategy:** To combine data from arrays of inverted echo sounders, bottom pressure gauges, current meter moorings, and horizontal electric field recorders with hydrographic data so as to provide a complete description of Gulf Stream structure and transport.

CIMAS Research Theme:

- **Theme 1:** Climate Variability
- **Theme 6:** Integrated Ocean Observations (*secondary*)

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

The Gulf Stream carries the upper limb of the Meridional Overturning Circulation as it flows through the Straits of Florida along the east coast of the Americas northward towards the Southeast Newfoundland Rise. As it moves off the continental shelf near Cape Hatteras the transport of the Gulf Stream begins to increase immensely, and by 68°W the transport has nearly quadrupled over that passing through the Florida Straits. Historically the Gulf Stream has been the subject of intense study, and it has become the archetype of a western boundary current in the sense that most studies of other currents refer to differences and similarities to the Gulf Stream. This project revisits one of the most complete studies of the Gulf Stream,

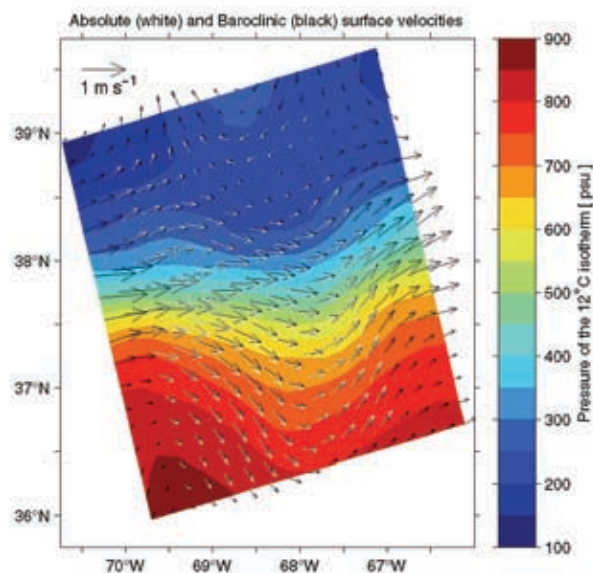


Fig. 1- Color contours show the two-year mean pressure of the 12°C isotherm within the mooring array. Also shown are the two-year mean absolute and baroclinic surface velocities, with the latter calculated relative to the bottom (absolute – white vectors; baroclinic – black vectors).

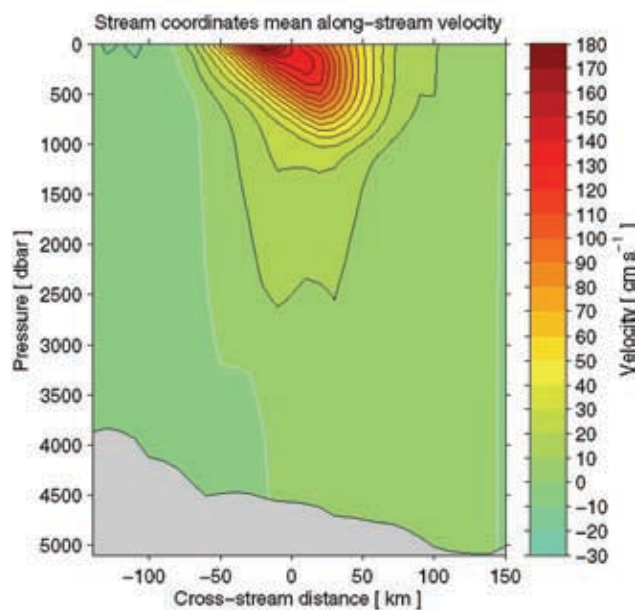


Fig. 2- Stream coordinates mean along-stream velocity. White contour denotes zero velocity.

the Synoptic Ocean Prediction (SYNOP) experiment, using analytical techniques that were unavailable at the time of the experiment. The objective is to see what can be learned using these improved techniques.

Significant progress has been made on this project over the past year. Data for each of the different measurement systems (inverted echo sounders, bottom pressure gauges, current meters, horizontal electric field recorders, moored acoustic Doppler current profilers, and conductivity-temperature-depth recorders) have been obtained from the various scientists involved in the SYNOP experiment, and all data has been loaded into a consistent database. We have combined the inverted echo sounder, bottom pressure gauge, deep current meter, and hydrographic data to produce 4-D data sets of temperature, salinity, and velocity. These data sets allow us to visualize the Gulf Stream on layers (e.g. Figure 1). It also allows us to do more advanced studies, such as developing a stream coordinates mean structure for the Gulf Stream that has better vertical resolution than anything previously completed (Figure 2).

Research Performance Measure: All research goals were met.

Mid-infrared Sea-Surface Temperatures During the Day: Retrievals into the Sun-Glitter Pattern

P. Minnett, R.H Evans and A. Kumar (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To develop and validate algorithms to derived sea-surface temperatures (SSTs) from measurements made from satellite-borne radiometers in the mid-infrared atmospheric window at about 3.7 μm wavelength during the day. Such measurements contain significant contributions from reflected sun-light (sun-glitter) and the conventional approach is to discard the data taken on the illuminated part of each satellite orbit.
- **Strategy:** Make use of the measurements from the MODerate-resolution Imaging Spectrometers (MODIS) on the NASA EOS Terra and Aqua satellites in conjunction with numerical radiative transfer models to explore the feasibility of extracting useful SST values in the regions of the sun-lit swath contaminated by the sun-glitter pattern.

CIMAS Research Theme:

- **Theme 1:** Climate Variability

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's ability to Plan and Respond.
- **Goal 3:** Serve Society's Needs for Weather and Water Information. (*secondary*)

Research Summary:

The essence of accurate sea-surface temperature measurement from satellite radiometers operating in the infrared is the effectiveness of the correction for the effect of the intervening atmosphere. The basis of the atmospheric correction is making simultaneous measurements in two spectral intervals in which the effects of the atmosphere are different. The difference in the two top-of-atmosphere brightness temperature measurements is related to the effects of the atmosphere, and an algorithm can be constructed to provide a correction at least in a statistical fashion. Generally this is achieved using measurements at 11 and 12 μm wavelengths in the thermal infrared atmospheric transmission window. The current version of the infrared imager on the NOAA GOES in geostationary orbit do not have this pair of channels (whereas earlier version did) rendering impossible this approach to SST measurement. A possible alternative is to combine top-of-atmosphere brightness temperature measurement from the 3.7 μm atmospheric window with the measurements at 11 μm . this works well at night, but the shorter wavelength measurements are contaminated by reflected sunlight during the day. This research is directed at exploring corrections for the solar contamination in the daytime 3.7 μm measurements prior to their use in an atmospheric correction algorithm for the derivation of SST.

The rationale of the research is the geometrical congruence of the reflection of the solar radiation in the visible part of the spectrum and that in the 3.7 μm atmospheric window. The approach is to determine the surface reflectivity in the visible measurements and translate this to the 3.7 μm measurements. This leads to an estimate of the solar radiation in the 3.7 μm measurement. Following correction for this component in the signal, the 3.7 μm measurement can be used in an atmospheric correction scheme for the daytime measurement of SST.

The research has focused on using MODIS data in a series of case studies, along with numerical simulations of MODIS measurements.

Thus far this approach has resulted in corrections for the solar component in the 3.7 μm measurements, but these are not yet at the level at which the corrected data can be used to derive SST to a useful accuracy. The possible cases for the residual uncertainties include:

- a) non-linear response of the visible and/or 3,7 μm detectors at high radiances

- b) spatial variations in the atmospheric transmissivity in the visible, and/or the $3.7\mu\text{m}$ wavelengths
- c) uncertainties in the aerosol correction, in particular in the phase function in the aerosol scattering in the visible and infrared.

Research Performance Measure: The research has followed the plans outlined at the outset. Several setbacks were encountered, such as the saturation in the sun-glitter pattern of the MODIS signals in most of the visible channels.

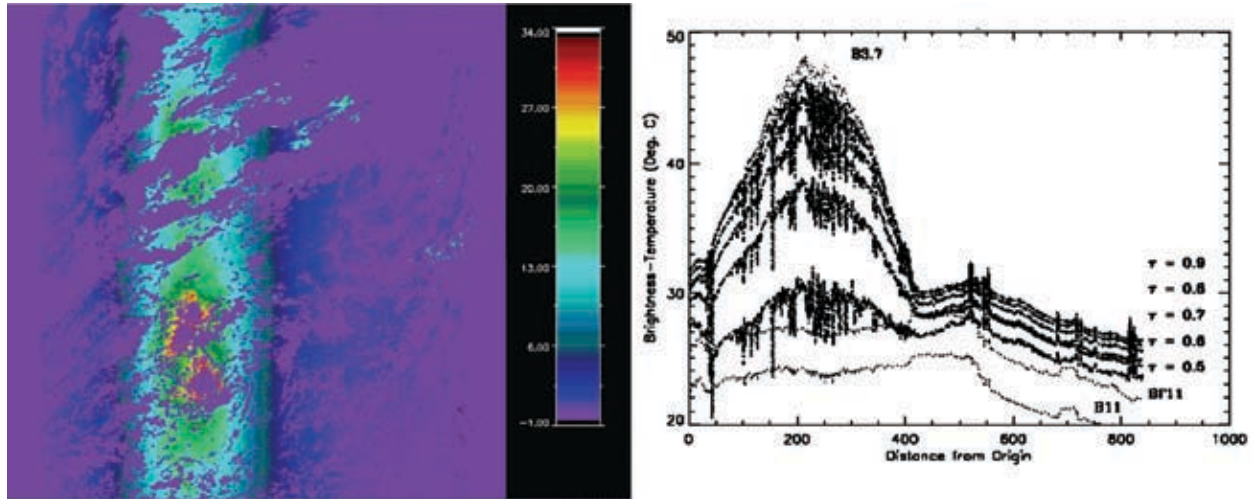


Fig. 1- The effect of sunglitter on SST measurement (left) revealed by the difference in the daytime SST derived from MODIS measurements in the thermal infrared at $11\mu\text{m}$ and in the mid-infrared at $3.7\mu\text{m}$. The dependency of the $3.7\mu\text{m}$ top-of-atmosphere brightness temperature on the atmospheric transmissivity (τ) across the sunglitter pattern is shown at right

Assessment of Decadal Variability in the Tropical Radiation Budget

B.J. Soden and A.C. Clement (UM/RSMAS); A.J. Broccoli (Rutgers Univ.)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To assess the decadal scale variability of the tropical radiation budget.
- **Strategy:** To compare satellite observations with empirical analyses and climate model simulations to evaluate the veracity and cause of decadal variations in the net radiation at the top-of-the-atmosphere.

CIMAS Research Theme:

- **Theme 1:** Climate Variability

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

A key disagreement exists between Global Climate Model (GCM) simulations and satellite observations of the decadal variability in the tropical-mean radiation budget. Measurements from the Earth Radiation Budget Experiment (ERBE) over the period 1984-2001 indicate a trend of increasing longwave emission and decreasing shortwave reflection which no GCM can currently reproduce.

Motivated by these results, a series of model sensitivity experiments were performed to investigate hypotheses which have been advanced to explain this discrepancy. Specifically, we assessed the extent to which a strengthening of the Hadley circulation or a change in convective precipitation efficiency can alter the tropical-mean radiation budget. Results from both model sensitivity experiments and an empirical analysis of ERBE observations suggest that the tropical-mean radiation budget is remarkably insensitive to changes in the tropical circulation.

The empirical estimate suggests that it would require at least a doubling in strength of the Hadley circulation in order to generate the observed decadal radiative flux changes. In contrast, rather small changes in a model's convective precipitation efficiency can generate changes comparable to those observed, provided that the precipitation efficiency lies near the upper end of its possible range. If, however, the precipitation efficiency of tropical convective systems is more moderate, the model experiments suggest that the climate would be rather insensitive to changes in its value. Further observations are necessary to constrain the potential effects of microphysics on the top-of-atmosphere radiation budget.

Cloud feedback is the leading cause of uncertainty in model predictions of climate change and it is believed to be the primary cause of the discrepancy between observed and model-simulated decadal variability in the tropical-mean radiative fluxes. However, the use of observed or model-simulated radiative fluxes to diagnose the effect of clouds on climate sensitivity requires an accurate understanding of the distinction between a change in cloud radiative forcing and a cloud feedback. We compared model simulations from different versions of the GFDL Atmospheric Model 2 which have widely varying strengths of cloud feedback to illustrate the differences between the two

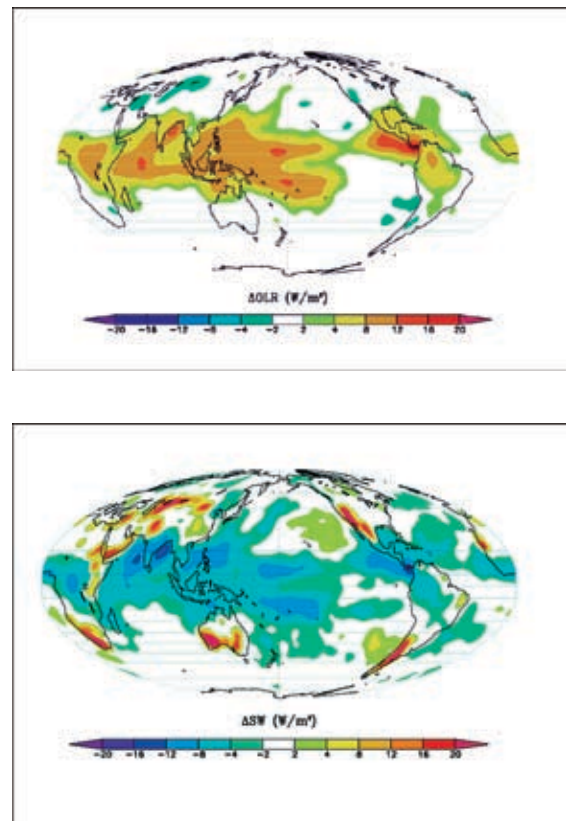


Fig. 1- The change in annual-mean TOA outgoing longwave radiation (top) and reflected SW radiation (bottom) simulated by the GFDL GCM for due to changes in the convective precipitation efficiency.

and to highlight the potential for changes in cloud radiative forcing to be misinterpreted. In particular, we show how positive cloud feedbacks can be associated with decreases in cloud radiative forcing. We suggest that while almost half of the models used in previous IPCC assessments have decreases in cloud forcing under warmer climates, most, if not all, of them actually have a positive cloud feedback.

Research Performance Measure: We have accomplished our major performance measures on schedule.

- 1) Assessed the sensitivity of the tropical radiation budget in GCMs to changes in the tropical circulation.
- 2) Assessed the sensitivity of the tropical radiation budget in GCMs to changes in cloud and convective microphysical parameters.
- 3) Performed a detailed comparison of cloud radiative forcing and cloud feedback in climate model simulations.

Studies of Climate Feedbacks and Sensitivity Using GFDL Models

B.J. Soden (UM/RSMAS); I.M. Held (NOAA/GFDL)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To provide a quantitative assessment of the strengths of climate feedbacks in current coupled ocean-atmosphere climate models.
- **Strategy:** To use the results from the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment model archive to compute climate feedback parameters from radiative adjoint calculations.

CIMAS Research Theme:

- **Theme 1:** Climate Variability

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

Climate models exhibit a large range of sensitivities in response to increased greenhouse gases due to differences in feedback processes which amplify or damp the initial radiative perturbation. Although the analysis and validation of these feedbacks are crucial tasks in climate change research, there has never been a coordinated assessment of climate feedbacks in models used for global warming projections. As a result, the relative magnitude of different feedback processes and their contributions to the range of climate sensitivities remain uncertain.

The objective of this task is to provide a quantitative assessment of the strengths of climate feedbacks in the NOAA Geophysical Fluid Dynamics Laboratory (GFDL) climate models and to facilitate a consistent intercomparison of these feedbacks with those simulated by other climate modeling centers. We have assessed the strength of model feedbacks using radiative adjoint calculations and the existing model archive of 21st century climate change experiments developed for the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (AR4).

Our results confirm two widely-held beliefs: i) that water vapor provides the largest positive feedback and behaves in nearly a constant relative humidity manner in all models; and ii) that clouds provide, by far, the largest source of uncertainty in current model predictions of climate sensitivity. However, these results also point out some less well recognized aspects of climate feedbacks: i) that clouds provide a positive feedback in all models (i.e., that they act to amplify climate sensitivity); and ii) that intermodel differences in lapse-rate response stem primarily from differences in the meridional distribution of surface warming.

Research Performance Measure: All objectives were accomplished on schedule:

- 1) Develop radiative adjoint kernels for temperature, water vapor, cloud and surface albedo feedbacks.
- 2) Perform calculations of the climate feedbacks from various IPCC AR4 climate models.
- 3) Assess the intermodel differences in various feedback parameters.

A Radiance-Based Analysis of Satellite and Radiosonde Records to Document Long-Term Water Vapor Changes

B.J. Soden (UM/RSMAS); D.L. Jackson (NOAA/CIRES); X. Huang (Princeton Univ.)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To assess the decadal scale variability of upper tropospheric water vapor.
- **Strategy:** To compare satellite observations with radiosonde measurements, reanalyses, and climate model simulations in order to evaluate the presence of radiative signatures of upper tropospheric water vapor trends.

CIMAS Research Theme:

- **Theme 1:** Climate Variability

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

The primary goal of this project is to perform a radiance-based analysis satellite and radiosonde observations and climate model simulations of upper tropospheric water vapor to quantitatively assess their long-term changes. Our research has focused on reprocessing the entire level-1b High Resolution Infrared Sounder (HIRS) radiance record to produce a consistent monthly-mean clear-sky and total-sky radiance products for all 20 HIRS channels. This data set was then used to test the fidelity of climate model simulated trends in upper tropospheric water vapor.

All climate models predict that the concentration of water vapor in the upper troposphere will increase dramatically in the future, possibly doubling by the end of the century. Such dramatic changes underscore the importance of upper tropospheric water vapor, both as a feedback mechanism and as an important diagnostic for climate change detection and attribution. However the validity of such projections has been debated for over a decade. Indeed some argue that the concentrations in the upper troposphere might actually decrease in a warmer climate; they express concerns about the simplified treatment of convection and cloud-related processes in current models because of the important role that they play in governing the distribution of moisture.

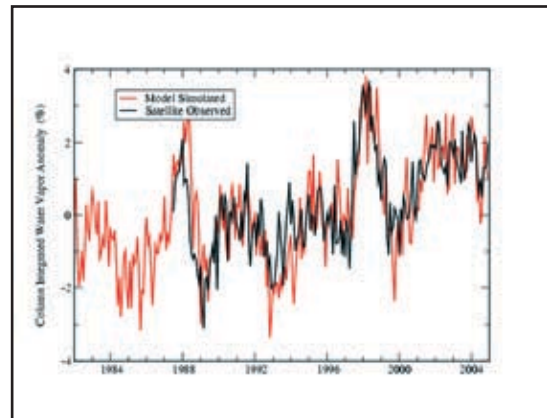


Figure 1. The global mean (ocean-only) anomalies in column integrated water vapor from GFDL atmospheric model simulations forced with observed sea surface temperatures (red) and satellite observations (black).

In this study, we used climate model simulations and the reprocessed HIRS satellite measurements to demonstrate the presence of a distinct radiative signature which indicates an upper tropospheric moistening over the period 1979-2000. The observed moistening is consistent with model simulations and corresponds approximately to a constant relative humidity increase in upper tropospheric moisture over this period. We further demonstrate that without such an increase in upper tropospheric water vapor, the model would be unable to reproduce the satellite-observed radiance records.

Research Performance Measure: The major objectives of this program have been achieved on schedule:

- 1) Reprocessing the level-1b HIRS satellite record into total-sky and clear-sky records.
- 2) Performing a detailed analysis of the impact of orbital drift in the satellite equatorial crossing times on the long-term trends in the satellite record.
- 3) Assessing the radiative signature of upper tropospheric moistening in the HIRS observations on decadal time scales in relation to that predicted by climate models.

Moisture Budget in the Intra-Americas Sea, its Transport into North America and their Roles in Warm-Season Precipitation

A.M. Mestas-Núñez (UM/CIMAS); C. Zhang and B.A. Albrecht (UM/RSMAS)

D.B. Enfield (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To explore the connections among the warm pool of the Intra-Americas Sea (IAS), its moisture budget, moisture transport from the IAS into North America, and warm-season precipitation over North America.
- **Strategy:** To integrate and correlate observations from a network of atmospheric soundings around the IAS, the Eta regional model analysis, the NCEP-NCAR global model reanalysis, the CMAP global precipitation, and other datasets.

CIMAS Research Theme:

- **Theme 1:** Climate Variability

Link to NOAA Strategic Plan Goals:

- **Goal 2:** Understand Climate Variability Enhance Society's Ability to Plan and Respond.
- **Goal 3:** Serve Society's Needs for Weather and Water Information. (*secondary*)

Research Summary:

In order to understand climate variability in a region, we must be able to estimate the moisture balance – that is, the relative amounts of evaporation, precipitation, and the net horizontal transport of moisture through the region lateral boundaries. To this end we use atmospheric observations and model analyses in and around the Intra-Americas Sea (IAS, i.e. Gulf of Mexico and Caribbean Sea) to evaluate the moisture fluxes in that region. We first estimate uncertainties in estimating the moisture fluxes using the Eta regional analyses for the period April 2002 – March 2004. The Eta analyses are 4-times daily and have a resolution of about 32 km. The water vapor estimates from the Eta analyses compare well with sounding estimates. The uncertainties in the moisture flux calculations due to the coarser space and time resolutions of the NCEP-NCAR global model reanalysis are small compared with the range of natural variability. This result allows exploiting the longer record (about 50 years) of the NCEP-NCAR reanalysis to study the variability of moisture fluxes in the IAS. We divided the IAS lateral boundary into four (north, south, east and west) segments and estimated the annual and interannual (i.e. two year and longer) variability of the moisture fluxes through each of them. Our seasonal results consist of a winter and a summer regime.

We find that during the winter the inflow of moisture through the IAS eastern boundary, plus the net evaporation in the IAS, balances the outflow through the western boundary. In summer, the budget can be split into zonal and meridional balances: zonally, the moisture inflow through the eastern boundary balances the outflow through the western boundary; meridionally, the inflow through the southern boundary plus the net evaporation in the IAS balances the outflow through the northern boundary. At the interannual time scale, we found associations with the Pacific North American (PNA) and El Niño-Southern Oscillation (ENSO) known climatic modes. The PNA signal links the moisture inflow through the IAS eastern boundary, the outflow through the IAS northern boundary, and precipitation in central US. The source regions for US precipitation associated with the PNA are the Gulf of Mexico and the area just east of the IAS. The ENSO variability is associated with the variability of the flows through the eastern and southern IAS boundaries. Our program thus provides a better understanding of the relationship of various climate variability modes on regional water fluxes. This in turn could lead to better forecasts of the impact climate variability on regional water budgets.

Research Performance Measure: Our objective was to study the variability of the moisture fluxes in and around the IAS and their relationship with precipitation. This objective was accomplished.

A Study on the MJO-ENSO Problem

C. Zhang (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To understand the effects of the Madden-Julian Oscillation (MJO) on the El Niño-Southern Oscillation (ENSO) cycle.
- **Strategy:** To test various MJO and ENSO interaction hypotheses through data analysis and numerical modeling.

CIMAS Research Theme:

- **Theme 1:** Climate Variability

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

We studied the effects of uncoupled wind stress variability, such as the MJO, using a hierarchy of coupled ENSO models (one model of intermediate complexity and three hybrid models). We estimated the MJO (including its low-frequency variability) from observations and added this estimate as an external forcing to the coupled models. The great utility of such a simplification is that the MJO is prescribed from observations and therefore is expected to add to the simulations an important piece of realism missing in the coupled models. This approach allowed us to study in great detail the sensitivity of the ENSO coupled system to the MJO and other sources of uncoupled variability. The main effect of the MJO on the ocean is to force intraseasonal equatorial Kelvin waves. The temperature anomalies associated with these waves typically originate in the subsurface, propagate eastward along the thermocline, and are manifest in the surface upon their arrival to the eastern Pacific. When the associated MJO-induced perturbations in sea surface temperature are allowed to interact with the atmosphere large interannual anomalies develop. As an example, Figure 1 shows a time-longitude section of the externally imposed wind stress forcing (panel c) and compares the wind stress and SST anomalies produced by one of the coupled models (panels d and e) with the observed values (panels a and b). The response of all the models to the MJO was highly linear and therefore we did not find significant rectification of high frequency forcing to the interannual timescales. The sensitivity of the coupled system to the low-frequency variability of the MJO was consistent in all the models used. We therefore conclude that the MJO can have a large impact on the tropical Pacific coupled system. This suggests that improving our capabilities to forecast the level of MJO activity will result in an increase in our ability to forecast ENSO.

Research Performance Measure: The main objective – to evaluate the effects of the MJO and differentiate the MJO from other types of stochastic forcing of ENSO – was accomplished.

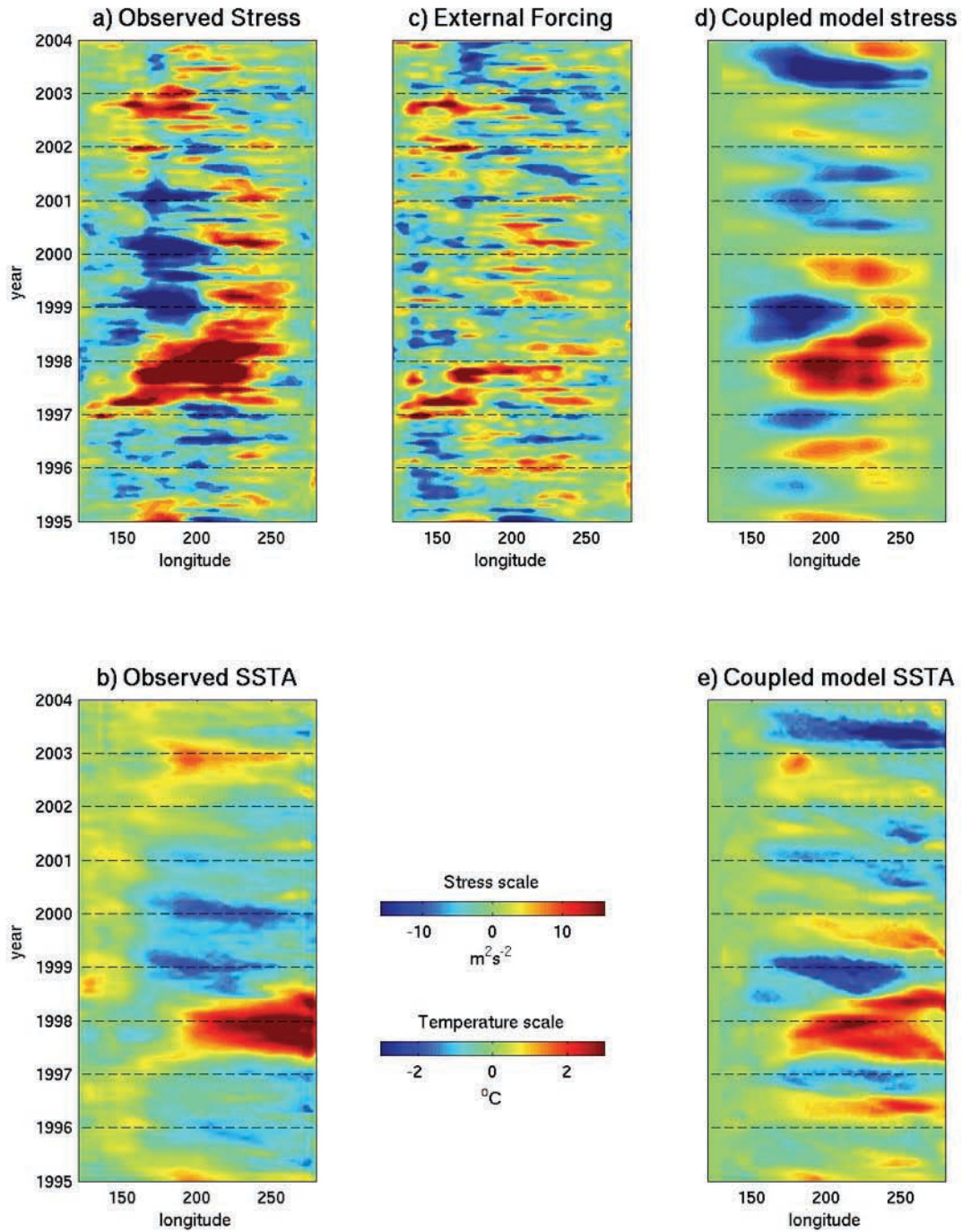


Figure 1. Response of an ENSO model to uncoupled atmospheric variability. (a) and (b) show the observed wind stress and SST anomalies along the equator. (d) and (e) show the wind stress and SST anomalies predicted when the model is forced with the uncoupled stress shown in (c).

CO₂/CLIVAR Repeat Hydrography Program CO₂ Synthesis Science Team

E.J. Millero (UM/RSMAS); R. Wanninkhof and T.-H. Peng (NOAA/AOML)
R. Feely and C.L. Sabine (NOAA/PMEL); R. Key (Princeton)
A. Dickson (Scripps); A. Kozyr (ORNL/CDIAC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To provide a core set of carbon and tracer measurements so as to generate a globally consistent data set as a contribution to NOAA's climate goal.
- **Strategy:** To conduct a global, decadal time-scale, sampling of ocean transports and inventories of climatically significant parameters.

CIMAS Research Theme:

- **Theme 1:** Climate Variability

Link to NOAA Strategic Plan Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.
- **Goal 3:** Serve Society's Needs for Weather and Water Information. (*secondary*)

Research Summary:

The NOAA/NSF Repeat Hydrography CO₂/tracer Program is a component of the Carbon Cycle Science Program (CCSP) and is a collaborative effort between NOAA and NSF to conduct a global, decadal time-scale, sampling of ocean transports and inventories of climatically significant parameters. It is part of NOAA's strategic climate goal of climate forcing. It provides a core set of carbon and tracer measurements and anticipates that additional carbon/CLIVAR measurements will be added to the cruises on an "as required" basis. The new data from this program is being synthesized into a globally consistent data set (e.g., corrected for recognized analytical errors and systematic biases) and combined with similar data sets from our international partners working on this same problem. This timely synthesis is critical for an adaptive sampling approach in which recent regional changes in carbon inventories are taken into account to design improvements in future sampling. A CO₂ Synthesis Science Team has been formed with PIs and investigators with expertise in data synthesis. Data sets are being gathered from national and international sources and are being synthesized into a single globally consistent data set. Interpretation of the data is a major component of this research.

During the 1990s ocean sampling expeditions were carried out as part of the World Ocean Circulation Experiment (WOCE), the Joint Global Ocean Flux Study (JGOFS) and the Ocean Atmosphere Carbon Exchange Study (OACES). Most of the cruises included various inorganic carbon species among the suite of routinely measured parameters. Both during and after the field work, a group of U.S. scientists collaborated to synthesize the data into easily usable and readily available products. This collaboration is known as the Global Ocean Data Analysis Project (GLODAP).

Both measured results and calculated quantities were merged into common format data sets, segregated by ocean. The carbon data were subjected to rigorous secondary quality control procedures, beyond those typically performed on individual cruise data, to eliminate systematic biases in the basin-scale compilations. For comparison purposes, each ocean data set included results from a small number of high quality historical cruises. The calibrated 1990s data were used to estimate anthropogenic CO₂, potential alkalinity, CFC watermass ages, CFC partial pressure, bomb-produced radiocarbon and natural radiocarbon. The calibrated-merged data were used to produce objectively gridded global property maps designed to match existing climatologies for temperature, salinity, oxygen and nutrients. Both the data sets and the gridded products are available from the Carbon Dioxide Information Analysis Center (CDIAC).

The synthesis was carried out one ocean at a time progressing from the Indian to Pacific and ending with the Atlantic. The entire synthesis required about five years. During that period new methods were developed and old ones modified. At the same time, the data set itself changed and expanded. Many of the GLODAP

results are already published. Important details of the data assembly, calibration, calculations, and mapping are described in a recent data report.

The GLODAP data set is available free of charge as a numeric data package (NDP-83) from the Carbon Dioxide Information Analysis Center (CDIAC). The data, and any subsequent updates, are also available through the GLODAP web site (http://cdiac.ornl.gov/oceans/glodap/Glodap_home.htm). The GLODAP bottle data files are available in flat ASCII file data format, in Ocean Data View (ODV) format, and through the CDIAC live access server (LAS); the gridded data files are available in flat ASCII and netCDF data file formats and through CDIAC LAS. Sabine et al. (1999, 2002a) and Lee et al. (2003) estimated the anthropogenic CO₂ distribution and inventory for the Indian, Pacific and Atlantic Oceans, respectively. The global synthesis for anthropogenic CO₂ was given by Sabine et al. (2004). The inorganic carbon chemistry for the three oceans was described by Sabine et al. (2002b), Feely et al. (2001, 2002) and Chung et al. (2003, 2004). Feely et al. (2004) published a global summary of the carbonate work. Millero et al. (2002) evaluated the thermodynamic inorganic carbon dissociation constants using a subset of the GLODAP data where the carbon system was over determined (i.e. more than two carbon parameters were measured). Finally, Key et al. (2004) summarized the data assembly and mapping procedures, discussed large scale property distributions and estimated global inventories.

Research Performance Measure: All current objectives are being met.

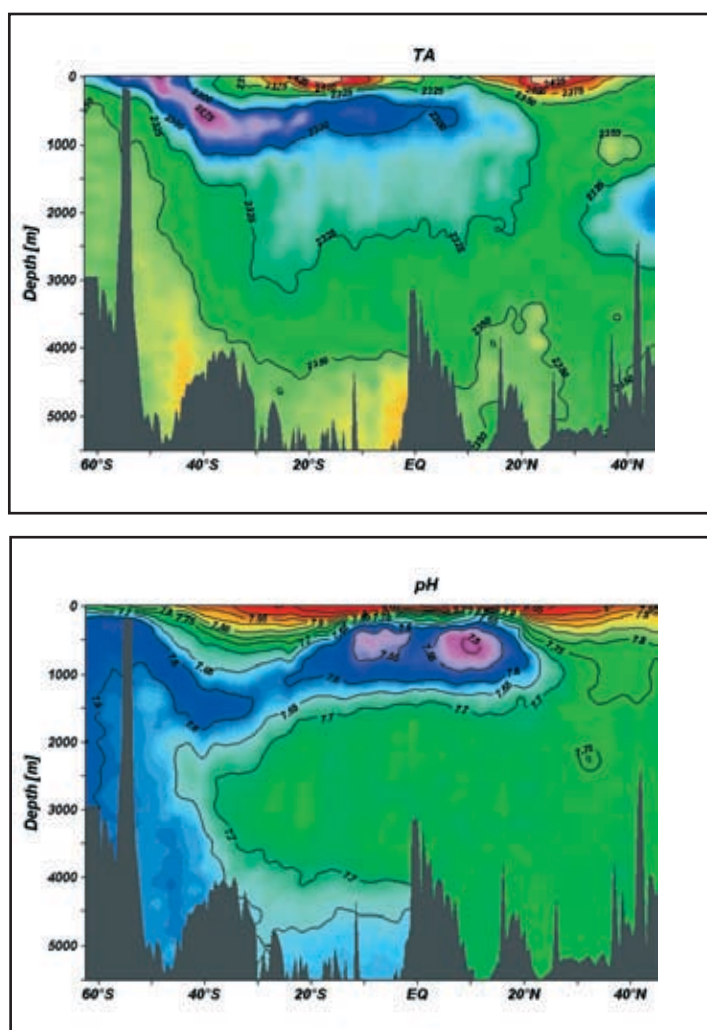


Fig. 1: Contour of the total alkalinity from the 2003 A16N and 2005 A16S cruises, TA in mmol kg . **Fig. 2:** Contour of the pH from the 2003 A16N and 2005 A16S cruises

Western Boundary Current Time Series Project

R. Garcia, C. Fonseca, H. Guarin , B. Kates, L. Gramer
G. Rawson, P. DiNezio, J. Redman and N. Melo, (UM/CIMAS)
M. Baringer, C. Meinen, S. Garzoli and E. Johns (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To monitor the meridional overturning circulation through sustained time series observations of western boundary currents.
- **Strategy:** To use a wide range of observations - satellite, hydrographic, moored instruments and submarine-cable measurements - to study the Florida Current, Deep Western Boundary Current and Antilles Current system.

CIMAS Research Theme:

- **Theme 1:** Climate Variability
- **Theme 6:** Integrated Ocean Observations (secondary)

Link to NOAA Strategic Goals:

- Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

Climate models have shown that variations of the transport of the Meridional Overturning Cell (MOC) in the Atlantic Ocean have significant impacts on the climate at both the national and global level. Near 26.5°N in the Atlantic the southward deep flow of the MOC is primarily located east of Abaco Island in the Bahamas. At that latitude the northward shallow flow is primarily carried between the Florida coast and the Bahamas, although some of the northward flow is carried east of the Bahamas. Long-term observations of the Antilles Current, Florida Current and Deep Western Boundary Current are required to quantify the natural scales of current variability.

This project maintains NOAA's well-established and climatically significant Florida Current volume transport time series. For the past 20 years we have made daily measurements of mean voltage-derived transports using out-of-service and in-use submarine communication cables that span the Straits of Florida. The cable voltages can be converted to physically meaningful transport estimates, i.e. intensity of the flow, using electromagnetic induction theory and data from calibration sections.

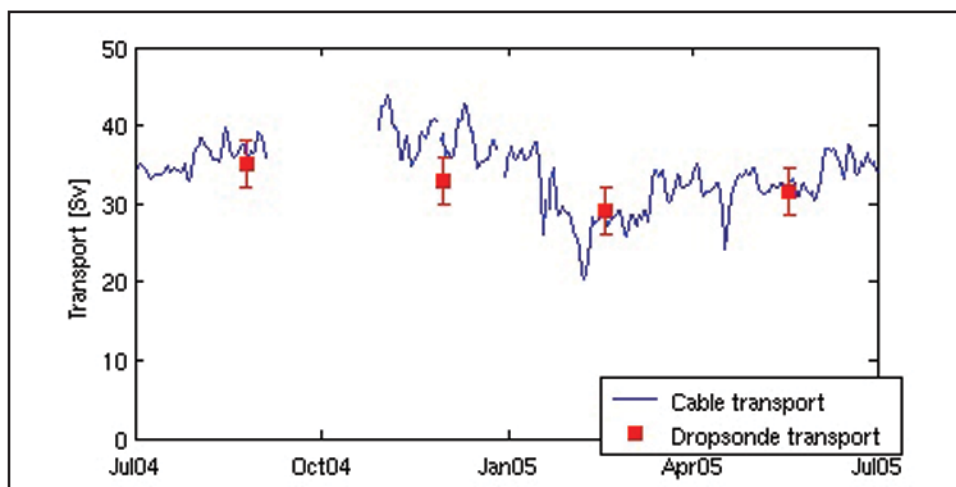


Figure 1: Time series of transport changes in the Florida Current as observed by submarine cable (solid line) and by shipboard measurements (symbols). Transports are in units of Sverdrups (1 Sv = 106 m³ s⁻¹).

This project also carries out repeated hydrographic sampling at Abaco which has yielded a high-temporal-resolution record of water mass properties in the Deep Western Boundary Current at 26°N. Events such as the intense convection period in the Labrador Sea and the renewal of classical Labrador Sea Water in the 1980's are clearly reflected in the cooling and freshening of the Deep Western Boundary Current waters off Abaco, and the arrival of a strong pulse of Labrador Sea Water approximately 10 years later. We have also developed a low-cost, accurate method for monitoring the transport of Antilles Current and Deep Western Boundary Current in the Atlantic Ocean east of Florida using bottom pressure gauges, inverted echo sounders, and hydrographic data (Meinen et al., 2004).

During the past year, the monitoring and data distribution system for the Florida Current cable program has been modernized. The program now provides transport estimates for the upper limb of the meridional overturning circulation in near real time via the web page www.aoml.noaa.gov/floridacurrent/. We recently collaborated with other researchers to produce a comparison between the transport fluctuations observed by the Florida Current cable system and those observed in a global ocean model run by at the Naval Research Laboratory. A publication detailing the results was recently featured in EOS (Mooers et al., 2005). Cable voltages were also calibrated to obtain heat transport time series of the Florida Current (Shoosmith et al., 2005). Furthermore we completed two hydrographic cruises to monitor water mass changes along 26.5°N east of Abaco Island in the Bahamas during the past year; one funded by NOAA on the NOAA R/V Ronald H. Brown, and the other funded by NSF onboard the R/V Knorr. The latter cruise involved recovering and redeploying an array of moorings that is monitoring the net flow across 26.5°N in the basin interior (the Meridional Overturning Circulation Heat-flux Array) as well as downloading data from three NOAA funded moorings via acoustic telemetry. We also conducted four calibration cruises (on the University of Miami's R/V Walton Smith) for cable transport and water mass changes within the Florida Current. We also organized 8 calibration cruises aboard small sport fishing boats chartered out of West Palm Beach.

Research Performance Measure: All research goals were met during this year.



Monitoring Coral Reef Fish Utilization of MPAs and Recruitment Connectivity between the Florida Keys and Meso-American Reefs

M.R. Lara and D.L. Jones (UM/CIMAS); J.T. Lamkin (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To investigate aspects of reproduction and transport of fish larvae and measure physical oceanographic phenomena in order to better understand the variables involved in the transport of these organisms to the coral reef ecosystem.
- **Strategy:** To carry out shore-based sampling of plankton with concurrent measurement of physical oceanographic variables at points along the Yucatan coast; to carry out an extended research cruise designed to gather plankton and physical data along the entire Yucatan coast; to apply newly developed methodologies using otolith microchemistry to answer questions about larval transport.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics

Link to NOAA Strategic Plan Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The aim of the study is to investigate aspects of reproduction and transport of larvae of fish inhabiting coral reef and tropical seagrasses and to measure physical oceanographic phenomena that may be involved in this transport. We are interested in the connectivity among different regions as sources and sinks of fish larvae and the large and small scale oceanographic processes that may be acting to determine the scale of this connectivity. Specifically we attempt to address the questions: (1) what physical oceanographic mechanisms are important in the transport of fish larvae and at what scale do these mechanisms come into play? (2) what patterns of larval fish distribution do they produce? (3) can newly developed methods of trace element analysis be applied to elucidate patterns of transport? and (4) can spawning aggregations known to occur off the Yucatan coast contribute as upstream sources of reef fishes to the Florida Keys and Dry Tortugas?

The long-term goal of this research is to establish the existence and degree of connectivity among sources and sinks of reef fish metapopulations. This is a necessary step for the proper management of fish stocks, the design and maintenance of Marine Protected Areas, and the establishment of essential fish habitats. We have begun the

collection of fish larvae over several years at various sites in Yucatan, Mexico. This region was chosen as a possible upstream source of larvae to Florida.

We have thus far completed three trips to the Yucatan. The first was to establish collaboration with researchers at the Mexican university El Colegio de la Frontera Sur (ECOSUR). The second trip was in 2004 to bring equipment and provide training in the field of the sampling techniques to be employed. Sampling was henceforth conducted each month of the year resulting in an extensive collection of fish larvae from a number of locations in Yucatan. In March 2005 we conducted the first extended sampling and monitoring study that involved the capture of fish larvae and simultaneous measurement and documentation of physical oceanographic phenomena. We obtained over 100 plankton samples using 3 different types of collecting gear. Moored physical oceanographic instruments have continued to collect data on current speed and direction and will do this for at least one year. Samples are currently being sorted for fish larvae. The outstanding result thus far has been the outstandingly high abundance of bonefish larvae in the spring of 2004. This high abundance was observed again in March 2005.

Research Performance Measure: All research objectives have been met.

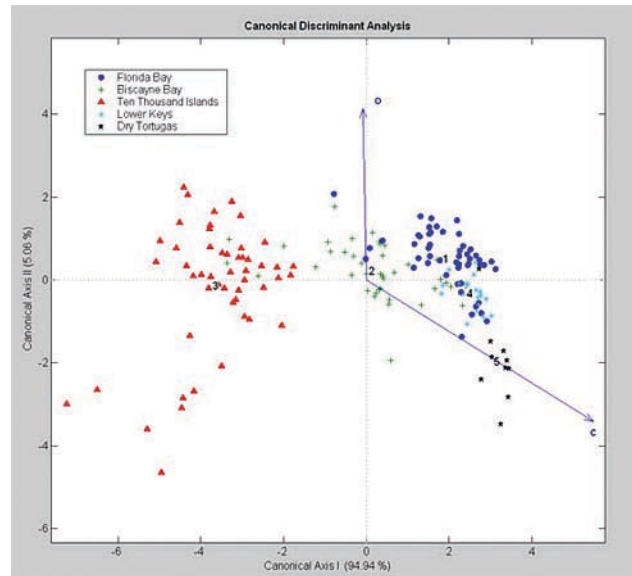


Fig. 1-Canonical discriminant analysis plot comparing elemental signatures in otoliths of juvenile gray snapper from five regions in South Florida. Each symbol represents an individual otolith (n=310); numbers (1-6) indicate the coordinates of the centroid of each group; correlation vectors are provided for each of the 8 elements found to significantly contribute to the signatures, vector length indicates the relative importance of each elements, vector heading shows the direction of the underlying gradient of each element.



Fig. 2-Monica Lara collects fish larvae using light traps deployed in 60' of water along the Mesoamerican barrier reef system off Xcalak, Quintana Roo, Mexico.

Modeling Connections Between Life Stages and Habitats

M. Criales and J. Wang (UM/RSMAS); J.A. Browder and
T. Jackson (NOAA/SEFSC); M. Robblee (USGS/CWRS)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To assess the impact on Florida Bay of upstream water management changes resulting from efforts to restore the Greater Everglades ecosystem.
- **Strategy:** To develop a pink shrimp simulation model that incorporates water management strategy options.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics

Link to NOAA Strategic Plan:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The pink shrimp (*Farfantepenaeus duorarum*), one of the most economically and ecologically important resources in South Florida, was selected as indicator species of the NOAA-South Florida Ecosystem Restoration Prediction and Modeling (SFERPM) to evaluate the impact of upstream water management changes in Florida Bay. Pink shrimp spawn offshore in the Dry Tortugas and planktonic stages migrate into the nursery grounds of Florida Bay where they settle and reside for several months before entering the adult population. Population dynamics of this species is thus strongly influenced by biological (larval behavior and life history characteristics) and physical (advection and diffusion) processes occurring in the SW Florida shelf in the Gulf of Mexico, Florida Bay and Florida Keys. Without an understanding of these processes it would not be possible to fully identify the controls of the variability of population abundance, thus hampering attempts at effective management of the ecosystem and the fishery.

During the first phase of our study we monitored the monthly influx of pink shrimp postlarvae at the entrance of the nursery grounds of Florida Bay for four consecutive years (2000-2003). Results of this first phase showed that the vast majority of postlarvae enter the Bay through its NW border, suggesting a potential northeast-eastward transport across the SW Florida shelf. A Lagrangian trajectory model coupled with larval behaviors was developed to estimate the drift of planktonic stages across the SW Florida shelf. Simulations of transport indicate that larvae moving with the instantaneous current and a diel behavior can travel up to 65 km, with 75% traveling only 30 km. The eastward distance traveled increased substantially when a tidal response was added to the model, up to a maximum of 200 km with 85% traveling 150 km. This mechanism requires that larvae/postlarvae migrate vertically in the water column to position themselves near the surface to take advantage of the strong eastward surface tidal flow that dominates the SW Florida shelf. However, when in larval development and where on the shallow SW Florida shelf the tidal response should be incorporated into the model was undetermined.

An oceanographic cruise was conducted in summer 2004 on the *R/V Gandy* with support of the SFERPM program and the NOAA-Pascagoula Laboratory, with the aim of improving our understanding of hydrodynamics at the SW Florida shelf and of larval behavior(s) of pink shrimp (Fig.1). Results of this cruise revealed a vertical stratification of the water column near Dry Tortugas and Marquesas (Fig. 2).

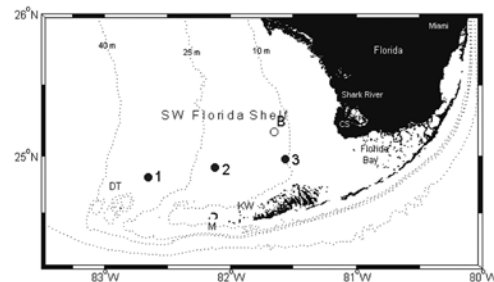


Figure 1. Map showing the location of the three stations sampled during the *R/V Gandy* cruise, conducted across the SW Florida Shelf on July 2-6, 2004. B is the location of a ADCP from Lee et al. ((UM-RSMAS/AOML-NOAA). Dt= Dry Tortugas, M= Marquesas, KW= Key West.

Time series of temperature and salinity indicated that the thermocline moved up and down, and the 27.8°C isotherm and the 36.24 isohaline intersected at the sea surface at periodic intervals of approximately 12 hours (Fig. 3). Simultaneously changes in current direction with increase of magnitude occurred at the thermocline between 8-12 m accompanied by a strong density gradient and instability of the water column.

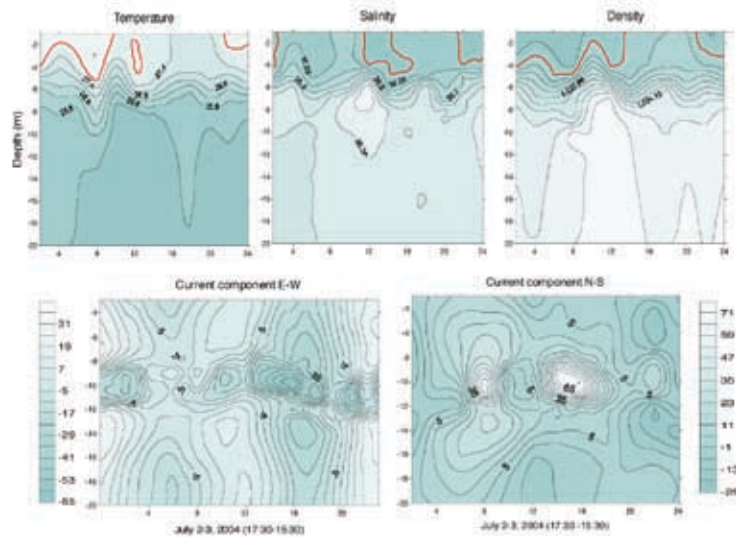


Figure 3. Vertical contours of temperature, salinity, density and current components recorded near Marquesas for a 24-hour period on July 2-3, 2004. Isotherms, isohalines and isopycnals oscillated periodically intersecting at the sea surface (red lines) at periodic intervals of approximately 12 hours. Current components (cm/sec), cross-shelf (E= east +, W= west -) and alongshore (N= north +, S= south) shows changes in current direction with increase of magnitude between 8 and 12 m.

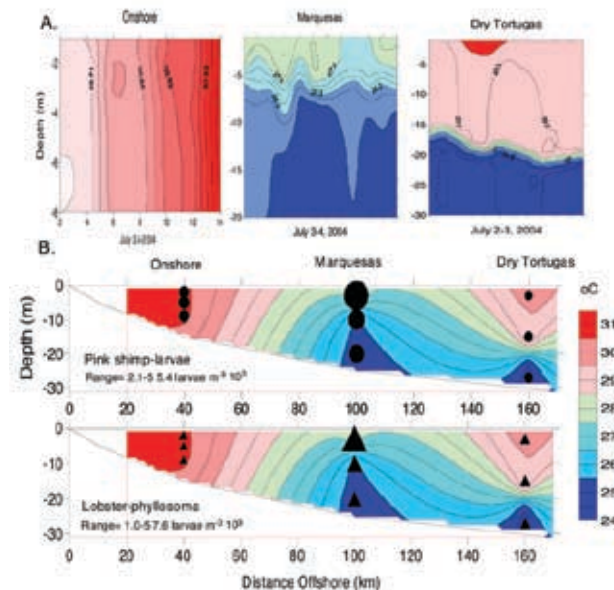


Figure 2 A. Time-depth plots of temperature recorded at three stations at the SW Florida Shelf. A thermocline was situated between 15 and 20 m of depth near the Dry Tortugas, and in the top 8 m near Marquesas. At the onshore station the water column was homogenous. B. Interpolated temperature contours across the transect show uplifted isotherms near surface at Marquesas, coinciding with a high concentration of pink shrimp larvae (all stages) and lobster (*Scyllarides* sp.) phyllosoma. The average of larval concentrations was superimposed on temperature contours and symbol sizes are proportional to concentrations.

All these features are typical manifestations of internal tides and associated internal bores. Internal tides have not previously been reported for the SW Florida Shelf, but their presence is not surprising since they often result from the interaction between tidal currents and bottom topography in a stratified water column over continental shelves and slopes. Pink shrimp larvae (myses and early postlarvae), rock shrimp (*Sicyonia* sp.) zoea and mysids, and lobster (*Scyllarides* sp.) phyllosoma were highly concentrated at the shallow thermocline at Marquesas (Fig. 2). Concentrations of pink shrimp larvae at this station were about five times higher than at the other two stations (near Florida Bay and near the Dry Tortugas) and lobster larvae were about three times higher than near the Dry Tortugas. These data reinforce our hypothesis that internal tides at the SW Florida shelf have a strong effect on larval cross-shelf transport.

Research Performance Measure: All objectives were met.

Implementation of the NOAA Southeast Coral Reef Database System (SeCoRDS)

J.S. Ault (UM/RSMAS), M.-L. Shyu (UM/Engineering);
S. Wong and P. Cope (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objective:** To develop innovative methodologies to address the issues of information management; spatial data search, access and analysis; and outreach for the SEFSC coral reef program.
- **Strategy:** To use advanced database systems to archive the data and to make it readily available to the community.

CIMAS Research Themes:

- **Theme 2:** Fisheries Dynamics
- **Theme 3:** *Regional Coastal Ecosystem Processes (secondary)*

Link to NOAA Strategic Plan Goal:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The database system incorporates Oracle database, Oracle iFS (Internet File System), Oracle application server, and Oracle Business Component for Java (bc4java). The system facilitates the communications among the coral reef managers (from the SEFSC, headquarters of NOAA Fisheries, and other NOAA line offices) and researchers via Web-based tools. Data access and analysis are improved through consolidation of the currently fragmented coral reef data sets in the SEFSC into a spatially enabled Oracle database management system (DBMS).

This program has provided substantial improvements on the development of the Web-based tools for coral reef program management and coordination. These have included the systematic organization of the coral reef metadata and a metadata generator customized for coral reef researchers. In addition, we have developed documentation for the system in terms of a computer-systems development manual and user tutorial manual.

Research Performance Measure: All objectives were attained on schedule.

Design and Development of the Caribbean-wide Reef Fish Visual Census Universal Database

J.S. Ault (UM/RSMAS), M-L. Shyu (UM/Engineers);
J.A. Bohnsack (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objective:** To develop a standardized, state-of-the-art, Caribbean wide, web-based data entry, error checking validation, storage, and report generating system for centralizing Reef Fish Visual Census (RVC) monitoring data collected with the stationary diver method.
- **Strategy:** Used advanced database systems to integrate and distribute environmental data.

CIMAS Research Themes:

- **Theme 2:** Fisheries Dynamics
- **Theme 3:** Regional Coastal Ecosystem Processes (secondary)

Link to NOAA Strategic Plan Goal:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The new Oracle database schema minimizes the complications with the existing old data such that the old data in the ACCESS database can be deployed into the new database with minimum efforts. The data entry program consumes very low processing power and memory capacity, and can automatically validate the data while providing an attractive user interface to the divers when they are collecting samples in the fields. A number of highlights of research accomplishments are:

- Modification of the Oracle database schema to better model all sample data collected by the divers.
- Improvement of the data entry program to better meet the user requirements.
- Improvements and modifications of the boatlog program to find the matching unit for the given location from the available GIS mesh unit, and to bind the data of the matching unit including MAPHAB, SUBREG, etc. to the boatlog record.
- Development of the batch process program to prepare the data in the form that can be deployed into the Oracle database.
- Development of the verification program to correct errors resided in the sample data and to match the boatlog records with the sample records to ensure the quality of the collected sample data.
- Product has been incorporated into regular use in the RVC monitoring program in the Florida Keys.

A number of Improvements were accomplished: (1) the user-friendly data entry program for the divers to enter the sample data collected in the fields, (2) the boatlog program to validate the collected sample data, (3) the batch process program to process the data, (4) the verification program to achieve better data quality, and (5) full development of the Oracle database.

Research Performance Measure: All objectives were accomplished on schedule.



Figure 1. Coral Reef Program home page

Settlement, Growth, and Migration of Snappers in Florida Bay and Adjacent Marine Ecosystems

M. Lara and D. Jones (UM/CIMAS); T.L. Gerard (NOAA/ SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To investigate and monitor the movement, migration and growth of juvenile stages of gray snapper in Florida Bay and adjacent marine ecosystems through the use of stable isotope analysis of their otoliths (carbonates).
- **Strategy:** Use stable isotope analysis of carbon and oxygen and otolith ageing to enhance understanding the size-age structure of juveniles in the Bay, their growth rates and migration patterns and how these relate to habitat characteristics and environmental variables such as salinity and temperature and ontogenetic shifts in habitat use.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

Stable isotopic ratios of carbon and oxygen, obtained from the otoliths of fish, have been well documented as useful tools for providing a wealth of information on environmental variations and stock structure of fish throughout their life history. Some of the valuable data include information about habitat temperature and salinity, migratory patterns and habitat use, diet and metabolic rates, and determination of the degree of stock mixing. In this study, we will investigate the size-age structure of gray snapper (*Lutjanus griseus*) juveniles in Florida Bay, examine their migration patterns, and explore how these relate to habitat characteristics and environmental variables such as salinity, temperature, and ontogenetic shifts in habitat. Our results are discussed in light of natural variability in population parameters such as recruitment and growth and how these parameters are influenced by natural environmental variability. Ultimately, we are optimistic that we can provide fisheries managers with valuable information on possible impacts of ecosystem change on gray snapper populations as a result of the implementation of the Comprehensive Everglades Restoration Plan.

Phase one of this study has been completed. Measurements were made of $^{18}\text{O}/^{16}\text{O}$ and $^{13}\text{C}/^{12}\text{C}$ ratios in the otolith carbonate obtained from juvenile gray snapper collected in 2001-2004 from various locations within Florida Bay and surrounding marine ecosystems. Results established that stable isotopes of carbon and oxygen allow for conclusive separation of fish from five regions in South Florida and specific sites within regions.

Phase two includes using a high-resolution Micromill drill to obtain samples along a cross section of individual otoliths thereby providing data over the life cycle of the fish. This will allow us to examine transitions in habitats and migrations between them.

Phase three involves determining the age of our juvenile samples by adding the daily calcium carbonate rings present on the otolith. Ultimately, we will establish a size-age growth curve to determine the age at which habitat transitions and migrations occur as well as provide baseline age to size data for general fisheries research and management purposes.

Research Performance Measure: Our first objective of examining fish from different regions to look for differences in isotope ratios has led to much success in the separation of these fish using the isotope ratios in their otoliths. Our second objective, to produce a length-age curve for juvenile gray snappers from Florida is underway and on schedule.

Photo-Identification of Bottlenose Dolphins in Biscayne Bay, Florida

J.A. Wicker (UM//CIMAS); L. Garrison and J.P. Contillo (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To understand and describe the parameters of bottlenose dolphin populations in Biscayne Bay; to monitor and observe their role in the south Florida ecosystem and the impacts of human activities on them; to advise decision-makers and inform the general public on the condition of the dolphin population in the Bay.
- **Strategy:** To develop and maintain a long-term database on bottlenose dolphin population parameters using photographic identification techniques which can be used to monitor the overall health of the Biscayne Bay ecosystem; to facilitate the sharing of bottlenose dolphin photo-ID information and images among research groups in adjacent study areas in south Florida via the Internet.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The National Marine Fisheries Service (NMFS) is responsible for monitoring the populations of bottlenose dolphins (*Tursiops truncatus*) in the southeastern United States waters. The main goals of this program are the detection of large-scale changes in bottlenose dolphin abundance and the establishment of archival databases for long-term trend detection. Biscayne Bay has been greatly impacted by development of the Miami area in the past century.

Biscayne Bay is home to a large resident population of bottlenose dolphins. Because of their role as apex predators, these animals can serve as excellent indicators of the overall health of Biscayne Bay. Aside from 20 aerial surveys (40 survey hours), conducted by Odell in the mid-1970's, very little formal research had been conducted on the abundance and distribution of bottlenose dolphins in Biscayne Bay prior to 1990. Under this present program, we have conducted in Biscayne Bay (from 1990-2004), a total of 322 photo-ID surveys comprising 1606 hours of sampling effort. Sampling has continued uninterrupted into 2005. These surveys have defined the basic parameters of the Biscayne Bay bottlenose dolphin population, including abundance, distribution, natality and mortality. To improve data management of photo-ID information in the SEFSC, and to facilitate efficient data sharing among other photo-ID research groups in south Florida, an Oracle database application was developed. This database enables "Internet web-based" online data entry, update, categorization, search, and download capabilities. The data resident on the system include scanned digital photos, associated collection information and meta-data, and allows viewing and sharing of this information between researchers and the general public via web browsers.

Continuation of the established photo-ID sampling regimen will provide the framework for defining biologically based management units and ultimately, understanding the consequences of anthropogenic influences on the bottlenose dolphin population in Biscayne Bay.

Research Performance Measure: This ongoing program is meeting all goal schedules.

Effort Response, Harvest, the Economy, and Climate in the Gulf of Mexico Recreational Fishery

D. Letson (UM/RSMAS); D.W. Carter (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To predict the effect of climate, economic, and regulatory changes on the value of recreational fishing in the Gulf of Mexico.
- **Strategy:** To develop models that can be used forecast recreational fishing effort and the value per unit effort or species; to predict the changes in effort and value expected with changes in the climate, the economy, and fisheries policy.

CIMAS Research Theme:

- **Theme 1:** Climate Variability
- **Theme 2:** Fisheries Dynamics

Link to NOAA Strategic Plan:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.
- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management. (*secondary*)

Research Summary:

The effective economic evaluation of fisheries rebuilding plans requires information on how policies will affect recreational fishing effort and harvest. This project addresses the need for models to forecast changes in recreational fishing effort and harvest. This program differs from others in that we attempt to include the effects of climate variability in the forecasts. We used 1986-2003 data from the Gulf of Mexico head boat fishery (a head boat is a vessel that charges a fee per passenger “head” for recreational fishing trips). We use these to model the relationships between aggregate effort, landings, the economy, climate, and regulations (Figure 1). The key fishery series included head boat angler days, red snapper landings, and size limits, and closed seasons. External influences were represented with indices for the ENSO (SOI), Bermuda High (BH), and hurricane (ACE) climate/weather phenomena as well as conditions in the U.S. economy (CFNAI).

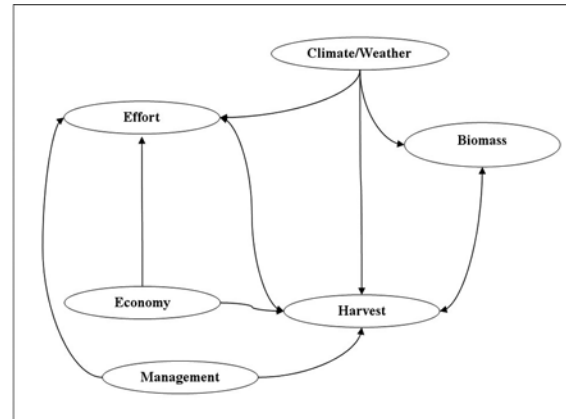


Figure 1: Functional relationship between various controlling factors in fisheries systems.

Formal econometric tests were performed to examine the time series properties of each variable used in the analysis. The results indicate that aggregate head boat effort and red snapper landings in the Gulf of Mexico are nonstationary, cointegrated variables. This means that external shocks or surprise events can permanently shift the mean of head boat effort and red snapper landings. However, the average relationship between effort and landings should only be temporarily affected by such shocks.

The effect of recreational fishing policies, climate and weather patterns, and overall economic activity on the Gulf of Mexico head boat fishery was evaluated using a structural vector error correction model. Results indicate that that bag limits have a positive effect, minimum size limits have a negative effect, and closures have a negative effect on red snapper landings in the Gulf of Mexico head boat fishery. However, only the minimum size limits have significant (positive) effect on head boat effort. We found that El Niño periods are associated with relatively higher effort and higher red snapper landings. Also, increased storm and hurricane activity contributes to relatively less effort and landings. Bermuda High fluctuations and conditions in the U.S. economy, however, have little, if any, contemporaneous effect on this fishery.

Research Performance Measure: The goals in the development of models and forecast information systems have been met on schedule.

Research and Development of Oracle Content Management System and Web Tools for the NOAA Southeast Coral Reef Research Program

M.L. Shyu (UM/Dept. Engineering); S. Wong and P. Cope (NOAA/ SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To investigate and develop innovative methodologies to address the issues of information management; spatial data search, access and analysis; and outreach for the SEFSC coral reef program.
- **Strategy:** Use state-of-the-art software development products to address data-management needs.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics
- **Theme 3:** Regional Coastal Ecosystem Processes (*secondary*)

Link to NOAA Strategic Plan Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The acquisition, review and dissemination of data in the SEFSC Coral Reef Program is a large and difficult task. Our program is working to put all phases of the program into a manageable coherent data structure. To this end we have used the latest development tools to produce software specifically adapted to this program. These include: Oracle Content Management Software Development Kit (CMSDK), Oracle database, Oracle application server, Oracle Business Component for Java (bc4java), ESRI ArcSDE (Spatial Database Engine), and ESRI ArcIMS (Internet Map Server) technologies.

We have developed an enhanced web interface that models the work flow of the proposal review process in the NOAA Coral Reef Proposal Review Platform (PReP). PReP provides the utility to facilitate the internal proposal review process of the NOAA Coral Reef Conservation Program by allowing the working group (WG) chairs/members an easy pathway for comment submission, collating, compilation, and reporting in the proposal review process. A web interface is provided for the users to submit their reviews and responses. The available reviews and responses can be displayed in a user-customized way.

The enhanced capabilities of the CMSDK can handle special requirements for the coral reef scientists, to ease their work and thus improve productivity. The developed tools incorporate utilities that facilitate program management, improve data access and analysis, increase productivity, and enhance public education/awareness of coral reef issues as well as SEFSC's role in conserving and protecting coral reef ecosystems.

The Oracle CMSDK provides a repository and information distribution mechanism such as the powerful data and metadata search functionality. The rich set of customization tools and Application Programming Interfaces (APIs) provided by Oracle CMSDK are utilized to development the functions required by the users.

Research Performance Measure: All objectives were attained on schedule or are on track.

The Collection of Fisheries Related Data from the U.S. Pelagic Longline Fleet by the Pelagic Observer Program

L. Mazuera (UM/CIMAS); D. Lee, L. Beerkircher and K. Keene (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To gather large-scale long-term statistical and biological fisheries data that are needed for conducting assessments of various Atlantic pelagic stock species.
- **Strategy:** To deploy NOAA-Fisheries certified observer personnel aboard the U.S. pelagic longline fleet to monitor effort and to observe the catch and bycatch of marine species while at sea during fishing operations. This work is carried out as part of the Pelagic Observer Program (POP).

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics

Link to NOAA Strategic Plan:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The SEFSC Miami Laboratory Pelagic Observer Program (POP) trains and places NOAA-Fisheries certified observers aboard commercial fishing vessels of the Atlantic U.S. pelagic longline fleet for purposes of collecting catch and effort data necessary for assessment and regulatory management of pelagic stocks such as tunas, billfishes, and sharks. In order to obtain a representative sampling of the Atlantic U.S. pelagic longline fleet



Fig.1: Typical U.S. pelagic longline vessel showing the mainline spool (center), hi-fliers attached at regular intervals along the mainline (right side of picture), and the vessel work deck.

effort, an eight percent sub-sample of the fleet is selected and notified each calendar quarter throughout the year. Since May of 1992, the SEFSC POP has observed over 850 pelagic longline trips in the waters of the northwest Atlantic Ocean. Observers have spent over 13,000 days at sea in which they monitored the catch and effort of 7,648 sets. The primary species of fish recorded are swordfish, yellowfin tuna, and a variety of shark species.

The certified observer personnel are trained by NOAA-Fisheries program staff in the identification of pelagic species of fish, the collection of statistical fisheries data and gear configuration, as well as support scientific research of marine species through the collection of biological tissues. The data collected by the POP are important in evaluating the effectiveness of stock management measures, as well as providing information for evaluating the stock status of harvested pelagic fish species such as swordfish and tunas. Within the international arena, these data have been used to compare catch and effort results with other countries prominent in similar Atlantic-wide fisheries.

The final stage of data collection is the transfer of the data from the observer data sheets to data files for the purpose of analysis by research scientists. This is accomplished through review of data sheets at observer debriefings and through interactions with data entry personnel and computer programming staff to expedite the data entry, quality control, and storage to provide ready access to the community.

Research Performance Measure: All performance measures have been met.



Fig. 2: An observer measuring the length of a yellowfin tuna carcass caught on pelagic longline gear.

Abundance and Diel Migrations Of Demersal Mesozooplankton and Small Reef Fishes: Their Trophodynamic Contribution to the Coral Reef Ecosystem

S. Smith, J. Luo, P. Lane, and D. Pilz (UM/RSMAS); P.B. Ortner, J.C. Hendee, S. Cummings and J. Stamates (NOAA/AOML); J. Lamkin and D. Jones (NOAA/NMFS)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To describe and quantify the functional bio-physical relationships and processes that control and impact planktonic processes associated with coral reef ecosystems.
- **Strategy:** To monitor the coral reef associated plankton community to provide basic information on habitat and population dynamics, with particular emphasis on biological responses to physical processes.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

A variety of autonomous sensors were deployed in the Salt River Natural Historical Park and Ecological Preserve on the north shore of St. Croix, USVI. This location was selected because of the proximity to a NOAA Coral Reef Early Warning System (CREWS) station. The study site includes a relatively vibrant coral community (Figure 1) in approximately 20-70 feet of water with nearby sandy bottom allowing non-invasive deployment of bottom-moored instrumentation. The research reported here was conducted during two field studies. The primary instrumentation utilized for this study consisted of an optical plankton counter (OPC), a multi-frequency Tracor Acoustical Profiling System (TAPS) and a 300 kHz RDI acoustic Doppler current profiler (ADCP) (Figure 2). A 1200 kHz ADCP was added during the May sampling period. In addition to the autonomous sensors, several plankton collections were made with a fine mesh net from a small boat during daytime and evening hours near the moored instruments. During the May study, SCUBA was used to collect plankton with a small push-net in close proximity to the OPC and TAPS.

Preliminary analyses of acoustic data showed distinct daily cycles of biomass fluctuation over the reef (Figures 3 and 4). These cycles are likely related to tides as well as to nighttime vertical migrations of zooplankton out of the reef and into the water column.

Laboratory analyses of net samples collected during day and night in late October and early May yielded information on the seasonal and diel plankton community dynamics near the reef. The abundance of total zooplankton was greater in October than in May. In October, total zooplankton abundance was greater in the morning and evening than in the afternoon, whereas in May, zooplankton abundance was greater in the afternoon than in the morning or evening. Planktonic larvae were often most abundant in the evening (dark) in both the October and May samples. These data suggest that the local current regime and the migratory behavior of some zooplankton species interact to modify the plankton community over the reef on a daily basis. For example, in the October net samples, three species of copepod (*Undinula vulgaris*, *Clausocalanus* sp. and *Oncaea* sp.) were much more abundant in the morning than in the afternoon or evening. This observation combined with current data suggest that these species were associated with a westerly flowing current, and coincidentally the incoming tide. The copepod *Temora turbinata* was more abundant in the night sample than in the day samples, suggesting this species may migrate upward from depth at night. Ostracods were also more abundant in the night sample, again suggesting that this group may migrate upward from depth after dark.

The results of the present study suggest that physical processes and zooplankton behavior play a complex interrelated role in controlling plankton ecology at the Salt River study site, and that the ecology of systems

upstream of the reef play a important role in the health of the reef. Further analyses of acoustical and optical data collected during the present study, and additional investigations of the behavior of specific zooplankton taxa near the reef may allow us to tease apart the effects of circulation and behavior on reef related zooplankton ecology. Understanding the bio-physical relationships and processes that control and impact planktonic processes associated with coral reef ecosystems is a critical step in predicting coral health and managing anthropogenic influences on coral reefs.

Research Performance Measure: The program objectives are being met on schedule. Ongoing analyses will provide a better understanding of the planktonic responses to circulation in the study area and how planktonic behavior affects the reef community.

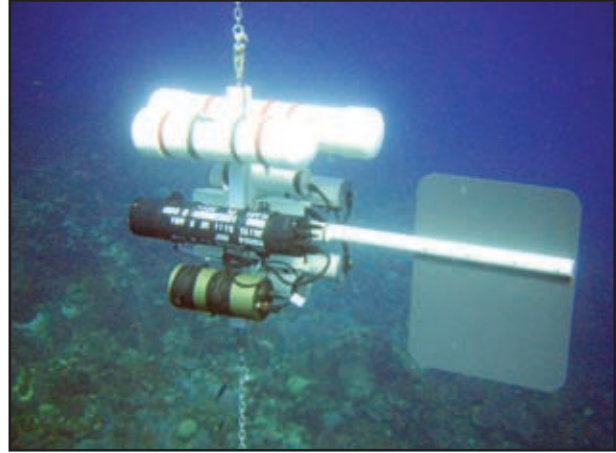
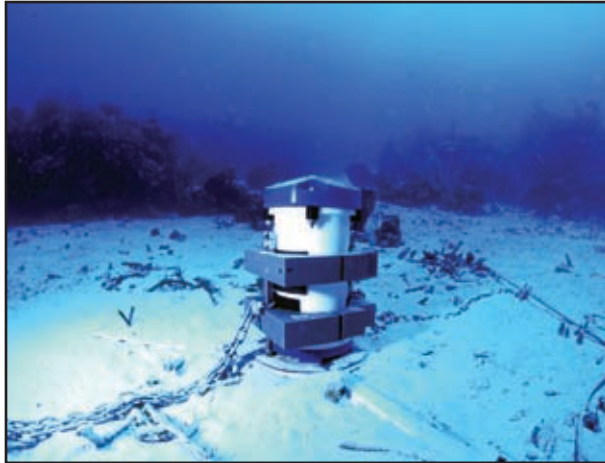


Fig. 1- Autonomous instruments for measuring water column plankton and currents. The photo on left shows the multi-frequency Tracor Acoustical Profiling System (TAPS) and the optical plankton counter (OPC) on a mooring with battery packs, buoyancy canisters and current vane. Photo on right shows 300 kHz acoustic Doppler current profiler (ADCP) mounted on sandy bottom adjacent to coral reef. Photos by P. Lane and J. Luo.



Fig. 2: Coral nearby moored instruments in Salt River Natural Historical Park and Ecological Preserve in St. Croix, USVI. (photo by P. Lane)

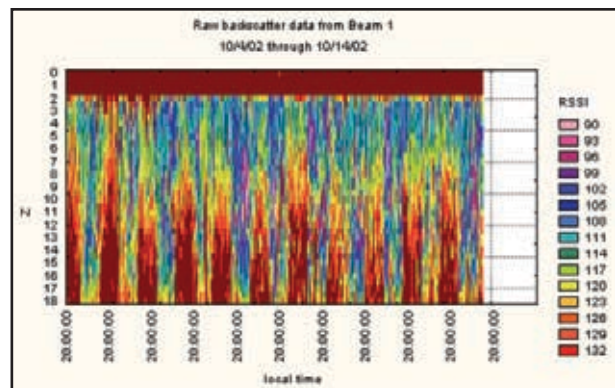


Fig. 3: Acoustic backscatter from the bottom moored 300 kHz ADCP for the 10 day period in October corresponding to TAPS data shown in figure 3. Diel periodicity suggests substantial cycles in planktonic biomass in the water column each day. Note that on the Y axis bin 18 is surface and bin 0 is the bottom (i.e., figure is inverted).

Passive Integrated Transponder (PIT) RFID Equipment Survey

L. Stokes (UM/CIMAS); S. Epperly and Lisa Belskis (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To increase the efficiency of leatherback mark/recapture studies in the Atlantic Ocean Basin in an effort to gain a more thorough understanding of leatherback migration patterns and nest site fidelity.
- **Strategy:** To conduct a quantitative assessment of the RFID scanners and Passive Integrated Transponder (PIT) tags, concentrating on equipment used for sea turtle research in the Atlantic Ocean Basin, and to survey researchers to determine technological compatibility problems.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

RFID (Radio Frequency IDentification) technology is used to permanently mark animals for mark/recapture studies. Researchers implant Passive Integrated Transponders (PIT tags), which are excited and detected with specialized scanners, into leatherback sea turtles. However, different projects throughout the Atlantic Ocean Basin use tags of various frequencies and scanners with varying capabilities, sometimes on the same population of animals. Our knowledge about leatherback movements and fidelity to nesting beaches in the Atlantic may be compromised by the incompatibility of tags and equipment being used. If researchers cannot detect previously implanted tags in nesting females, they may erroneously double count individuals that are also nesting on nearby beaches during population census surveys. The history of tagged turtles that strand or nest in regions other than their original tagging site will be unknown to fellow researchers if the scanning technology is incompatible, and much knowledge will be lost.

We surveyed leatherback researchers of the Atlantic Ocean Basin to identify the RFID tags currently in use (125 kHz, 125 kHz encrypted, 128 kHz, and ISO 134.2 kHz). Only the North American researchers are using readers capable of detecting all 3 frequencies, but only one project is using a reader that can detect the encrypted tags. Furthermore, the read distance for most of the readers being used in North America is

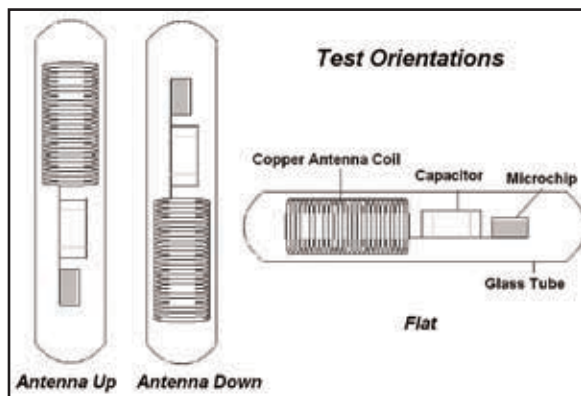


Fig. 1- Internal anatomy of a Passive Integrated Transponder (PIT tag), shown in the three orientations used for testing.



Figure 2. Experimental layout. PIT tag scanner on vinyl tiles with embedded PIT tag.

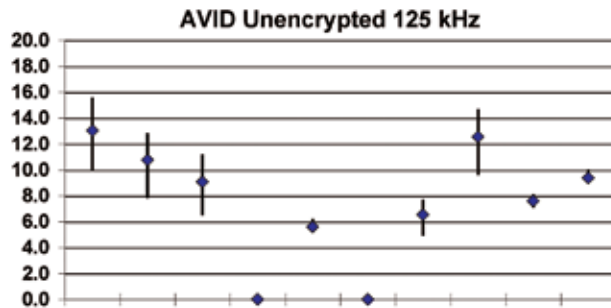


Figure 3. Example results graph depicting the range and mean read depth for one of 7 tag types, the AVID unencrypted 125 kHz PIT tag, for 10 scanner models (5 AVID models, 1 Trovan model, and 4 Destron models).

minimal for leatherbacks given the current tagging location, so tags in the 100+ leatherbacks stranding dead annually on U.S. Atlantic and Gulf beaches might go undetected. The equipment incompatibility problem is especially acute in the Caribbean, where most nesting occurs. Researchers in the Guianas and Africa are using 128 kHz tags and are using readers capable only of reading that same frequency. Throughout most of the Caribbean, including on nearby Trinidad, researchers mainly are implanting 125 kHz unencrypted tags, but historically have also implanted encrypted tags, and are using scanners that are not capable of reading tags from the Guianas, nor the rare ISO tags.

We tested 10 readers and 7 types of RFID tags (3 tag replicates and 3 orientations). To determine a measurable read depth, we stacked vinyl tiles upon a base containing the tag until the scanner reliably (3 con-

secutive times) detected the tag, but could not detect it at a greater depth. We corrected the measurements to represent the distance between the center of the tag and the base of the reader. We found that battery charge was very important and, thus, we always maintained freshly charged batteries in the units.

We summarized these results and presented them to researchers so that a clear picture of the gaps in technological compatibility could be seen and discussed. Ultimately, researchers using this technology on shared populations should incorporate these results to modify their equipment selection and eliminate the potential for undetected tags in the future.

Research Performance Measure: The preliminary phase of this research is complete as scheduled. We have conducted tests on all currently available scanners, but more units will be tested as they become available.

Pelagic Longline Sea Turtle Mitigation Research: Loggerhead Oral Cavity Morphometrics

L. Stokes and M. Burgos (UM/CIMAS); S. Epperly, L. Belskis,
D. Hataway and B. Higgins (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To reduce the incidental capture and mortality of sea turtles in pelagic longline fishing gear.
- **Strategy:** To investigate the morphometric parameters and ontogeny of the oral cavity in loggerhead sea turtles as related to fishing hook dimension.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

In order to expand our understanding of the interaction between sea turtles and hooks on pelagic longline fishing gear, we investigated the morphometric parameters of the oral cavity in loggerheads. Of particular interest

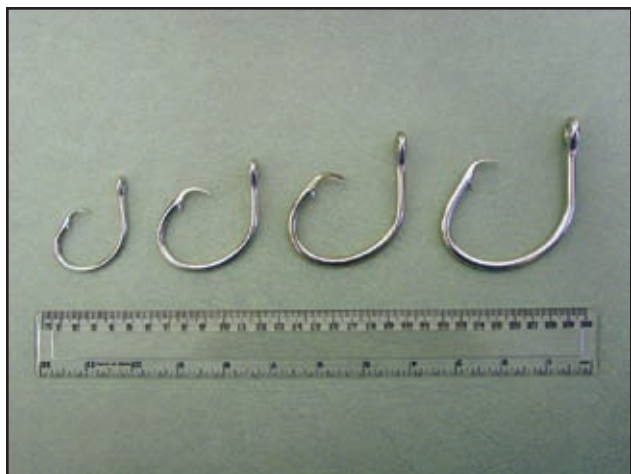


Figure 1. 14/0, 16/0, 18/0 and 20/0 circle hooks.

were how these measures relate to the size parameters of hooks currently fished in the pelagic longline fisheries, and how the internal parameters correlate with easily obtained external measures.

We performed a series of measures, both standard and specific to the oral cavity, on 210 loggerheads ranging in size from 35 cm-80 cm straight carapace length, spanning the range of turtle size classes most often incidentally captured. These measures included: mass, straight carapace length (SCL) notch-to-notch (minimum) and notch-to-tip (maximum), straight carapace width (SCW), head length (HL), head width (HW), gape height, internal gape width, esophagus width, upper jaw length and lower jaw length. We used both captive reared and wild caught turtles in this study. Using a standard canine mouth gag to hold open the animal's jaws, we took oral cavity measures with inside spring calipers and/or dial calipers.

These measures will be analyzed to develop an understanding of how the oral cavity changes as turtles grow. We will also measure hooks commonly used in pelagic longline fisheries to compare the anatomical characters of the oral cavity to hook diameter. Fisheries observers often take the standard external measures when they encounter an incidentally captured turtle onboard a fishing vessel, but the oral cavity measures are likely too difficult for them to obtain under these field conditions. We plan to develop mathematical relationships between the standard external measures easily collected and oral cavity measures. Using these relationships, we may predict the ability of a turtle of a given size to ingest hooks and the associated risk for injury. With this knowledge, we hope to reduce or prevent future incidental capture and mortality through mitigation measures.

Research Performance Measure: We have recently completed the data collection portion of the research, and will focus in the near future on analyzing the data.



Figure 2. Measuring straight carapace width (SCW) with calipers.

Mapping Effort and Harvest in Puerto Rico's Recreational Fishery

H. Stone (UM/CIMAS); D.W. Carter and B. Gentner (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To estimate the economic value and impact of recreational fishing at coral reefs around Puerto Rico.
- **Strategy:** To obtain information about the distribution of recreational fishing effort and landings around the island and then determine the value of the amount related to coral reef habitat.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics
- **Theme 4:** Human Interactions with the Environment (secondary)

Link to NOAA Strategic Plan:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The Marine Recreational Fisheries Statistics Survey (MRFSS) is conducted by the National Marine Fisheries Service to develop estimates of fishing effort and catch in the territorial U.S. During 2003-04, special questions were added to the MRFSS in Puerto Rico to elicit information about where people fished and where they caught fish. These additional questions were augmented by a series of maps to assist anglers and interviewers in identifying fishing locations. The maps were created from a Geographic Information System (GIS) constructed at the Southeast Fisheries Science Center in Miami. Responses to the mapping questions were recorded along with the other information collected by the MRFSS, such as species targeting preferences and the number and size of fish harvested and released.

We used the Puerto Rico MRFSS data for November 2003 through February 2004 to demonstrate the GIS created for this project. There were over seven hundred usable interviews conducted during this period. In the interviews recorded, there were more than sixteen hundred fish caught. Based on the data and suggestions from resource managers, the several species were selected for the mapping exercise. Figure 1 shows an example map depicting targeting preferences and catch for dolphin. These types of maps are mainly descriptive at this point because they are based on MRFSS interview data that has not been expanded to account for estimates of total fishing effort. As such, the maps are not necessarily representative of targeting or catch frequencies in the population of anglers. However, by viewing the targeting preferences and catches on the same map we can discern, for example, differences in success rates across areas. The maps can also help fishery managers and stakeholders understand the potential displacement in fishing effort associated with proposed marine protected areas.

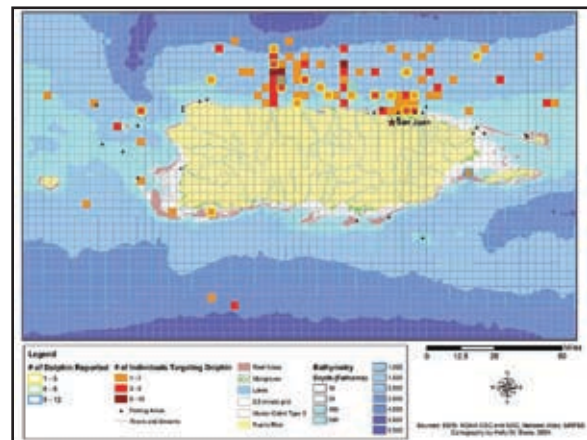


Fig. 1- Dolphin Targeting and Catch in Puerto Rico: November 2003 to February 2004.

Research Performance Measure: The goals in the development of the GIS and preliminary maps of effort and landings have been met on schedule.

Pelagic Longline Sea Turtle Mitigation Research: Hook and Bait Feeding Trials

L. Stokes and M. Burgos (UM/CIMAS); S. Epperly, J. Watson, D. Hataway,
C. Bergmann, L. Belskis, B. Higgins, D. Foster, J. Gearhart and L. Saxon (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To reduce the incidental capture and mortality of sea turtles in pelagic longline fishing gear.
- **Strategy:** Develop an empirical understanding of the interaction between loggerhead sea turtles and baited hooks.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

As a follow-up to field research conducted in 2001-2003 in the Western Atlantic Northeast Distant Waters (NED), we conducted carefully controlled laboratory feeding trials to further investigate methods to reduce incidental capture and post-hooking mortality in sea turtles. We investigated the effects of hook size, animal size, bait type and baiting technique as they relate to loggerhead sea turtles' ability to swallow a baited hook. We modified 14/0, 16/0, 18/0 or 20/0 circle hooks by removing the barb and wrapping the end to prevent injury to the turtle and baited (either "single hooked" or "threaded") the hooks with whole squid or sardines. We offered the baited hooks to captive reared loggerheads in three size classes (45, 55, and 65 cm straight carapace length). A recorder coded the turtle's reaction based on its response: "did not take hook into mouth," "hook partially in mouth," "hook fully in mouth," or "attempted to swallow." If a turtle attempted to swallow a baited hook, we removed the hook immediately to prevent any risk of injury. A videographer taped the interactions to further elucidate behavioral details of the interaction.



Figure 1. "Single hooked" sardines on 14/0, 16/0 and 18/0 hooks.

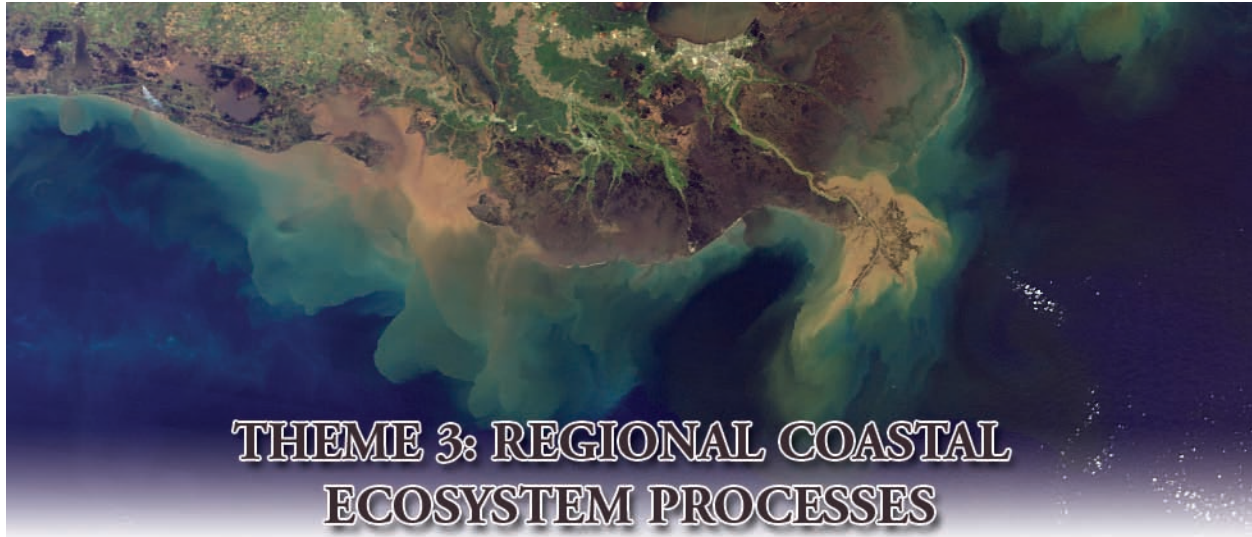
As expected, results from the study indicated that as hook size increased, the potential for full ingestion decreased, reducing the likelihood of a serious injury. As the turtles increased in size, though, so did their ability to swallow the larger hooks. Turtles were less likely to fully or partially ingest hooks baited with sardines than those baited with squid. They were also less likely to fully or partially ingest "single hooked" bait than "threaded" bait, as single hooked bait was more likely to tear away. These results are likely due to the differences in bait texture, potential shielding effects of the bait, and behavioral differences in how turtles feed on different bait types.

Fishing with larger circle hooks (18/0 or greater) single baited with finfish such as sardines would reduce injury or mortality resulting from incidental capture in pelagic longline gear. Smaller hooks baited with squid (the industry standard prior to the 2001-2003 NED research and subsequent rule modifications) pose a much greater risk for serious injury or mortality.

Research Performance Measure: Our research goal, to conduct feeding trials using turtles representing the size classes most often encountered with longline gear, has been attained. The laboratory trials provided the opportunity under controlled conditions to confirm preliminary data collected in field trials with large sample size and statistical confidence. These data can be used to strengthen the mitigation measures recently enacted to reduce incidental capture.

Figure 2. “Single hooked” squid on 14/0, 16/0 and 18/0 hooks.





Demographic Monitoring of *Acropora palmata* in the Florida Keys

D.E. Williams, and B. Mason (UM/CIMAS); M.W. Miller (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To determine the relative importance of each 'threat' (disease, predation etc.) among the remaining elkhorn populations in the upper Florida Keys
- **Strategy:** To assess on a quarterly basis the status of individually-tagged colonies of coral at several sites in the upper Florida Keys National Marine Sanctuary (FKNMS)

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:

Elkhorn coral (*Acropora palmata*) is one of the dominant framework builders on Caribbean reefs. Because of its structural complexity and very fast growth rates it is ecologically irreplaceable on Caribbean reefs. Elkhorn populations in the Florida Keys and throughout the Caribbean have declined by more than 90% since the 1980s. The remaining population is faced with a variety of natural and anthropogenic pressures that threaten population-level recovery including disease, predation, fragmentation and overgrowth by sponges and algae. Elkhorn coral is currently being proposed for listing as 'threatened' under the Endangered Species Act. If the proposed listing is approved NOAA Fisheries will develop a recovery plan based on the current status and threats to these corals in US waters.

The overall objectives of this project are to document the status and distribution of the remaining elkhorn populations in the upper Florida Keys and to determine the relative importance of the various 'threats' (disease, predation etc) present in those populations. This project consists of a mapping and demographic monitoring components. The monitoring component is conducted at fifteen study plots established at 5 reefs in the upper FKNMS. All elkhorn colonies in the study plot were carefully mapped and approximately 12 colonies within each plot were selected randomly and tagged (n=188). Every three months the tagged colonies are photographed and assessed for the presence of any threats and the entire study plot is searched for new 'recruits' to the population.

To date we have observed that disease has had the most profound impact on the population. While the pathogen remains unidentified, disease manifestations are generally consistent with white pox. Prevalence of this disease varies greatly over space and time, generally increased in the summer months. Predation also varies over space and time and results in tissue loss, but at a much slower rate than disease. In spite of the very active 2004 hurricane season, relatively little physical damage resulted from the hurricanes. However, Hurricane Dennis in July 2005 caused widespread fragmentation and likely exacerbated disease impact on the population (Fig.1). Two thirds of tagged colonies showed active disease signs that coincided precisely with the hurricane. At the last survey approximately 70% of the storm generated fragments were rapidly losing tissue which suggests that asexual recruitment will be minimal.

The mapping component of this project aims to survey shallow reef areas and mark *Acropora* spp. colonies using GPS. These points along with surveyed tracks are entered into a GIS database. The resulting map will provide a valuable tool for monitoring long term changes in the status of this threatened species.

Research Performance Measure: All aspects of this program are successfully on schedule.



Figure 1. Tagged *Acropora palmata* colony at Elbow Reef in the Florida Keys in May 2005 and the same colony 4 days after Hurricane Dennis passed approximately 400 km to the west. Note the dramatic decrease in size due to fragmentation of the colony and the large bright white areas indicating freshly exposed (within 3 to 4 days) skeleton (rectangular board is 30cm, photos have been scaled to equivalent size for comparison).

Biscayne Bay Coastal and Nearshore Community Baseline Study to Develop Biological Performance Measures: Faunal Density and Community Composition of the Nearshore Zone

J. Hall and D. Smith (UM/CIMAS); J. Browder (NOAA/NMFS);
M. Robble and D. Reed (USGS)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To characterize the nearshore epibenthic faunal community in South Biscayne Bay and explore relationships of faunal density and community composition to salinity and other environmental variables.
- **Strategy:** To carry out stratified random sampling with three types of gear (roller-frame trawl, pull-net, and throw trap), and to relate faunal density to environmental variables (both as categorical variables and as gradients) using statistical techniques.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Plan Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The project has four main **objectives**: (1) determine fish, shrimp, and crab density and diversity in the shallow nearshore habitat in Biscayne Bay using throw-traps, commercial shrimp vessels (roller-frame trawls), and pull-nets; (2) compare pink shrimp population dynamics between shallow (< 1 m) water nearshore zones and the deeper (> 1m) zone fished by the live-bait roller-frame fleet; (3) evaluate the influence of salinity, geographic location, and habitat on fish, shrimp and crab community structure and pink shrimp population dynamics in Biscayne Bay; (4) compare density estimates and species diversity based on data from three types of sampling gear.

The study area is located along the western side of the nearshore region of southern Biscayne Bay between Shoal Point (Chicken Key) to the north and Turkey Point to the south. The throw-trap component includes a reference site located in the nearshore area of eastern Biscayne Bay adjacent to Elliott Key. The stratified random sampling design distinguished two geographic zones (Geozone), three salinity zones (Salzone), and two depth zones (Depthzone). Fish and invertebrates were the target species. Animals were weighed for total biomass, then sorted and identified to a practical taxonomic level.

In the statistical models of the samples collected with the roller-frame trawl, latitude and salinity were highly significant in describing density of pink shrimp. Figures 1 through 4 portray the spatial variation in the density of pink shrimp, as sampled by the

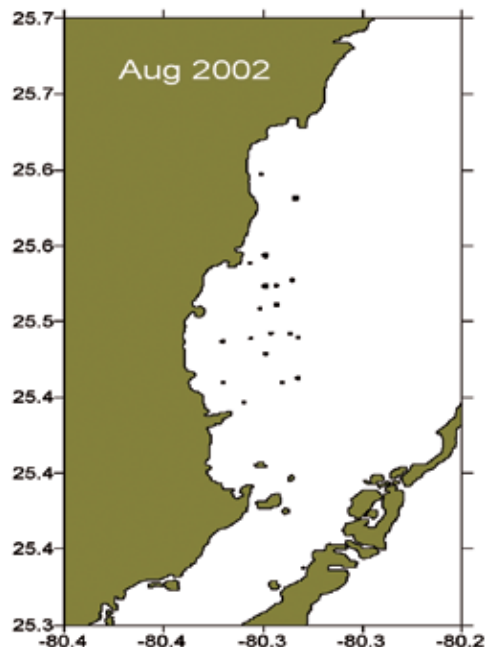


Figure 2. Shrimp Densities for commercial roller-frame trawl for February 2003.

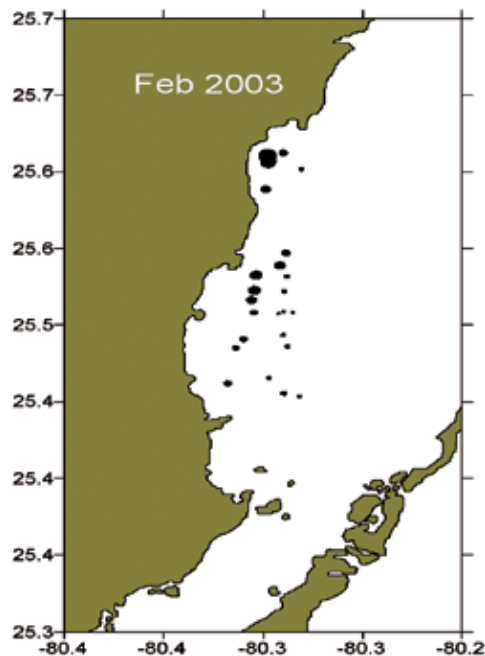


Figure 1. Shrimp Densities for commercial roller-frame trawl for August 2002

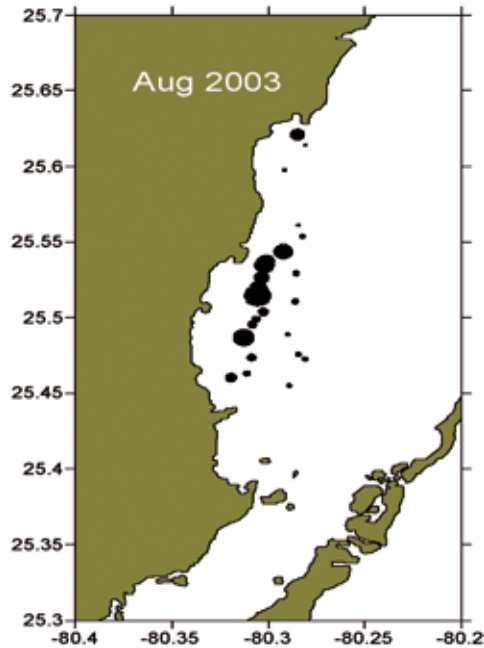


Figure 3. Shrimp Densities for commercial roller-frame trawl for August 2003.

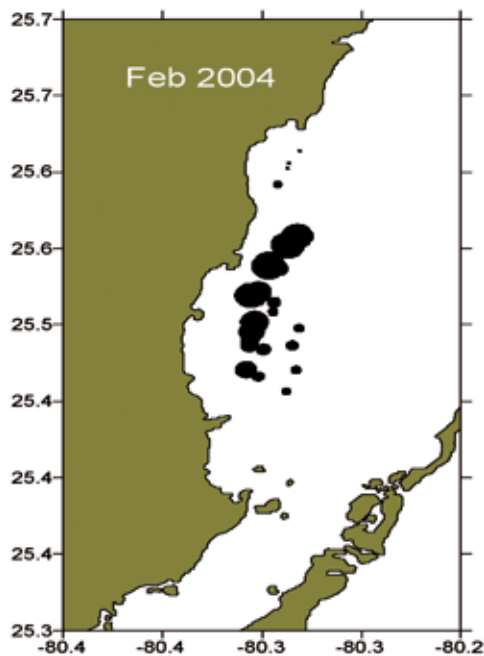


Figure 4. Shrimp Densities for commercial roller-frame trawl for February 2004.

roller-frame trawl. Shrimp densities were higher in the northern zone than in the southern zone. A notable difference in the zones was that the salinities were moderate to high in the northern zone whereas in the southern zone they were lowest and most variable. However the difference in shrimp densities may reflect an influence of spatial patterns in features other than salinity, for example, bottom habitat. Density increased from August (Figure 1 & 3) to February (Figure 2 & 4) in both years, suggesting recruitment of postlarval shrimp to Biscayne Bay nursery areas during the months of June and July. Caridean shrimp, important in the diet of pink shrimp, were extremely abundant in Biscayne Bay and, by number, the dominant component of the trawl collections. Latitude was a significant factor explaining variation in the density of six fish species. Three species (dusky pipefish, dwarf seahorse, and rainwater killifish) were denser in the north, the hardhead silverside was denser in the south, and two species (hermit crab and tomtate) were densest near Black Point. Salinity was a significant factor explaining variation in the density of ten species (all but dwarf seahorse and hardhead silverside). Eight species were denser at salinities in the lower part of the salinity range in the area sampled by the trawl and two species (dusky pipefish and tomtate) were densest in the middle of the area's salinity range.

The species models with continuous variables suggested that species distributions are influenced by collection date, salinity, and factors in addition to salinity that vary by latitude. Pink shrimp and most fish are more abundant in the inshore area, the unfished zone; but there is no clear suggestion in these data that fishing pressure is the cause of the lower density of most fish species in the deeper waters of the study area. The differences are due more likely to habitat differences than to fishing pressure. Analyses of throw-trap data suggested that the influence of salinity in the distribution and abundance of dominant species in the study area is small compared to that of habitat and other unknown factors.

Research Performance Measure: All objectives were accomplished as planned.

Effect of Salinity and Temperature on the Sediment/Water Exchange of Phosphorous: Predicting Response of Phosphorous Cycling to Increasing Freshwater Flow into Florida Bay

X. Huang (UM/RSMAS); J.Z. Zhang (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To quantify the effect of salinity and temperature on sediment/water partitioning of phosphorus in Florida Bay.
- **Strategy:** To carry out systematic experiments to quantify sediment characteristics for P exchange, such as the zero equilibrium phosphate concentration, the distribution coefficient, and P buffering capacity of sediment over a range of water salinities at different ambient temperatures.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

Phosphorous is an important nutrient in water-sediment systems. The zero equilibrium phosphate concentration, the distribution coefficient, and P buffering capacity of sediment are essential in water quality models for predicting the effect of increasing freshwater input, as proposed by the Comprehensive Everglades Restoration Plan, on the P cycle in Florida Bay. We quantified the effects of salinity and temperature on sediment/water partitioning of phosphorus by using a systematic approach. Based on our previous study on spatial distribution of sedimentary phosphorus in Florida Bay, we chose sediment samples based on both different sediment characteristics and on geographic region of the bay. Because the microbiological activity in sediments can have a significant impact on P cycling in the sediment/water system, we found that it was necessary to add CH_3Cl to the incubation systems to suppress this activity, particularly in experiments at higher temperature.

For a given station location, we studied individual sediment characteristics for P exchange, such as the zero equilibrium phosphate concentration (ZEC), the distribution coefficient, and P buffering capacity of sediment. We have investigated 5 sediments from selected stations in Florida Bay, each at 6 salinity conditions (2-72) and at three temperatures (15, 25 and 35°C). Our preliminary results indicated that the ZEC of sediment were positively correlated with the salinity of seawater, whereas the P buffering capacity of sediment were increased with increasing ambient temperature. This study will continue, focusing on sediments from different areas of the Bay.

Research Performance Measure: The research program is on schedule and all performance objectives are being met.

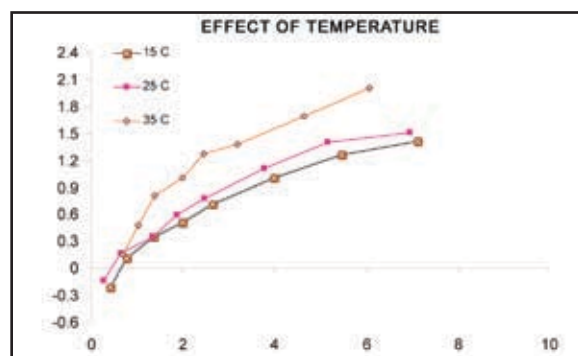


Fig.1. Typical effect of ambient temperature on the sediment characteristic with respect to sediment/water exchange of phosphorus in Florida Bay.

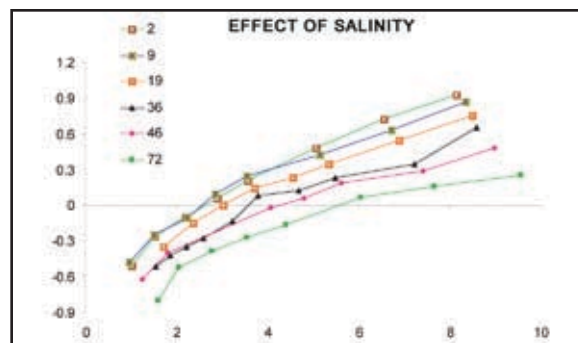


Fig.2. Typical effect of salinity on the sediment characteristic with respect to sediment/water exchange of phosphorus in Florida Bay.

Population Dynamics and Early Life History Processes in Corals

M.J.A. Vermeij (UM/CIMAS); M.W. Miller (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To understand coral population dynamics in relation to environmental variability through both space and time so as to lead to better management strategies for the recovery of Caribbean corals reefs especially those in the Florida Keys.
- **Strategy:** To study the early life history processes in corals and the impact on their survival.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

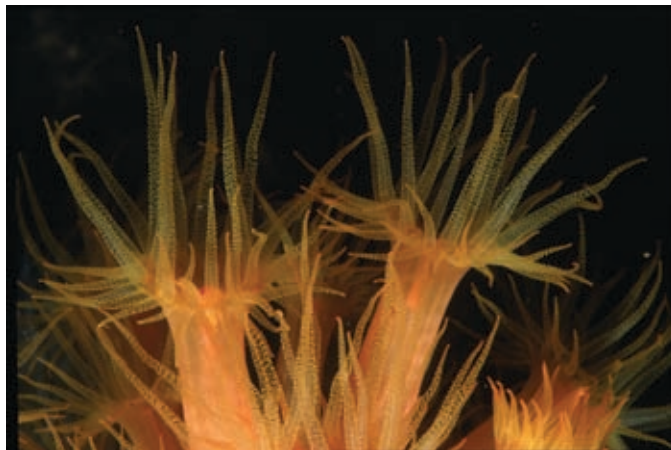
- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

We carried out a laboratory study of the early life-history dynamics of several major Caribbean species, in particular *Montastraea faveolata*, *Acropora palmata*, *Siderastrea radians* and *Agaricia humilis*. Survival and appropriate habitat choice of a coral planula are dependent to a degree on its earlier experiences in the plankton stage. Coral planulae show behavioral responses during the presettlement period indicating that their survival and dispersal may be determined in part by factors other than those that are purely stochastic (e.g. currents, predation). While it is premature to speculate on the implications of this laboratory behavior by extrapolating these results to the field, the potential importance of presettlement processes should nonetheless be carefully considered as an additional important factor in coral population dynamics.

In addition, increased habitat quality (in terms of the presence of “open” space and coverage by crustose coralline algae) and adult cover improve local settlement rates. The degree to which these factors affect local settlement rates is however variable through time and disappears during extreme disturbance events such as the 2004 Florida hurricanes. During the hurricanes extreme sand scour eradicated nearly all juvenile and adult coral colonies thereby “resetting” local colonization trajectories. The degree to which population densities decreased depended on local (i.e. at a 10m² scale) sedimentation rates.

In contrast to recruit survival, juvenile growth rates were highly variable and unrelated to benthic community structure, at least at the scale of this study. Competing benthic organisms affected coral recruitment success through space preemption (mainly by macroalgae) or recruit overgrowth (mainly by sponges).



The results highlight the small spatial scale (mm-cm) at which the processes occur that are responsible for the success or failure of recruitment and they emphasize the need to include such small scale observations in studies of coral early life-phase dynamics.

Research Performance Measure: All research goals were met.

Figure 1-*Tubastrea coccinea* shows a variety of growth strategies that allows it to successfully invade Caribbean coral communities.

Reef Fish Community Dynamics and Linkages with Florida Bay

J.S. Ault and S.G. Smith (UM/RSMAS); J.A. Bohnsack (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To quantify community and reef fish population changes from management actions associated with Everglades Restoration in Biscayne Bay and Florida Bay and different levels of protective spatial management in the Florida Keys.
- **Strategy:** To use integrated regional biological and physical spatial data sets from the south Florida ecosystem to facilitate design and development of statistical and analytical models to assess coral reef fish populations and to predict their future abundance

CIMAS Research Themes:

- **Theme 3:** Regional Coastal Ecosystem Processes
- **Theme 2:** Fisheries Dynamics (secondary)

Link to NOAA Strategic Plan Goal:

- **Goal 1:** Protect, Restore and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:

Our research seeks to understand and describe the ecological and biological dynamics of reef fish species and the economic impacts of human uses as a basis for sound management decisions. It provides critical data needed to assess and model the effects of the Everglades Restoration and spatial management strategies on coral reef fishes. Many exploited reef fish species directly use Florida Bay as critical settlement and nursery habitats before reaching maturity when they migrate back to the reefs as adults. Thus, any changes in Florida Bay and Biscayne Bay will result in changes in recruitment, growth, and mortality that will ultimately be reflected in reef fish species abundance, size, and distribution in the coral reefs.

This research established baselines data for the Florida Keys using a state-of-the-art sampling strategy. The research has also monitored reef fish community abundance and biomass trends by habitat types at sites from Miami through the Lower Keys with different levels of exposure to Florida Bay and Biscayne Bay influences due to coastal water management strategies and their relationship to areas under different levels of spatial management protection along the inshore and offshore reef tract. Study sites included areas managed by the Florida Fish and Wildlife Conservation Commission (FFWCC), Biscayne National Park (BNP), Everglades National Park (ENP) in Florida Bay (FB), the South Atlantic Fishery Management Council (SAFMC), and the Florida Keys National Marine Sanctuary (FKNMS).

A key aspect of this research program was designed to directly test specific hypothesis involving no-take marine reserves and their importance to reef management following the establishment of 19 no-take zones in the FKNMS in 1997. Specifically, this project collected data from years 3 and 4 following reserve establishment to elucidate the relative importance of fishing as a cause of ecosystem changes, and to precisely measure the successes of the southern Florida Ecosystem restoration efforts. Establishment of one large (79 km²) Ecological Reserve near Key West and 18 smaller (0.16-4 km²) no-take Sanctuary Preservation Areas (SPAs) in the middle and upper FKNMS provided a unique opportunity to address the influence of fishing. Fishing and other human extractions are recognized as a major disturbance to coral reefs. The establishment of no-take zones provides a control that will allow scientists to distinguish between natural changes versus anthropogenic disturbances. Determining the response of reef fish populations to no-take protection also provides a potential estimate of rates of change that could potentially occur following Everglades restoration.

These data suggest that fishing has been a dominate factor influencing reef fish community structure. Baseline data collected from recently established no-take reserves will eventually permit managers to model design and implementation strategies, to evaluate the efficacy of these measures, and to distinguish between possible impacts on reef fishery resources from changes in water quality from Florida Bay and Biscayne Bay and from those due to fishing.

Research Performance Measure: The objectives were attained and the reef fish community dynamics and linkages monitoring and modeling activity continues as planned.

Monitoring Coral Reef Fish Populations in the Florida Keys

J.S. Ault and S.G. Smith (UM/RSMAS); J.A. Bohnsack (NOAA/NMFS)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objective:** To augment the South Florida Ecosystem Restoration Program by providing a comprehensive quantitative evaluation of trends in FKNMS no-take zones: Sanctuary Preservation Areas (SPAs), Ecological Reserves (ERs), and Research Areas.
- **Strategy:** To carry out state-of-the-art multispecies assessments in the region, mapping coral reef habitats, and spatially-based monitoring of coral reef fish in the Florida reef tract.

CIMAS Research Themes:

- **Theme 3:** Regional Coastal Ecosystem Processes
- **Theme 2:** Fisheries Dynamics (secondary)

Link to NOAA Strategic Plan Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

No-take reserves (NTRs) in the Florida Keys National Marine Sanctuary (FKNMS) are a joint fishery and ecosystem management effort between the NOAA National Marine Sanctuary Program, National Park Service (NPS), and the State of Florida. The FKNMS has implemented three types of no-take areas: (1) 16 small Sanctuary Preservation Areas (SPAs) totaling approximately 46 km² that protect the high-relief coral reef; (2) one large (30 km²) ecological reserve (ER) that includes several different habitats; and, (3) 4 special-use SPAs designed for research purposes. Two large Ecological Reserves, 206 and 312 km², were added in 2001 west of the Tortugas, Florida. The NPS Service has scheduled a 100 km² Research Natural Area (RNA) for implementation in the western half of Dry Tortugas National Park.

The main objective was to design and conduct comprehensive surveys of coral reefs and reef fish stocks along the Florida coral reef tract. Simultaneous assessment surveys were conducted of fishes, corals, conch, spiny lobster, other reef species and coral reef habitats using newly developed state-of-the-art sampling strategies. Results have been used to define current baseline conditions and to monitor future changes that result from management actions in Biscayne National Park, the Florida Keys National Marine Sanctuary, and Dry Tortugas National Park. Regionally-synoptic monitoring and assessment expeditions, led by Drs. Ault and Bohnsack, have included participation by scientists from many state and federal agencies, several universities, and a volunteer non-profit organization. Although still early in the recovery process, our results are encouraging and suggest that NTMRs in conjunction with traditional management, can potentially help build sustainable fisheries while protecting the Florida Keys coral reef ecosystem.

The NOAA/NMFS Southeast Fisheries Science Center Coral Reef Initiative is supporting University of Miami RSMAS scientists in implementing interdisciplinary research on multispecies fisheries dynamics in the Florida Keys and wider Caribbean coral reef ecosystems. Quantitative baseline assessments were conducted on data collected from Biscayne National Park and Dry Tortugas National Park for design and analysis of their coral reef monitoring plans.

Research Performance Measure: The objectives of this program are being met by the extensive monitoring program that is currently underway.

Biscayne Bay Coastal and Nearshore Community Baseline Study to Develop Biological Performance Measures: Faunal Density and Community Composition of the Nearshore Zone

J. Hall and D. Smith (UM/CIMAS); J. Browder (NOAA/NMFS);

M. Robble and D. Reed (USGS)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To characterize the nearshore epibenthic faunal community in South Biscayne Bay and explore relationships of faunal density and community composition to salinity and other environmental variables.
- **Strategy:** To carry out stratified random sampling with three types of gear (roller-frame trawl, pull-net, and throw trap), and to relate faunal density to environmental variables (both as categorical variables and as gradients) using statistical techniques.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Plan Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The project has four main **objectives**: (1) determine fish, shrimp, and crab density and diversity in the shallow nearshore habitat in Biscayne Bay using throw-traps, commercial shrimp vessels (roller-frame trawls), and pull-nets; (2) compare pink shrimp population dynamics between shallow (< 1 m) water nearshore zones and the deeper (> 1m) zone fished by the live-bait roller-frame fleet; (3) evaluate the influence of salinity, geographic location, and habitat on fish, shrimp and crab community structure and pink shrimp population dynamics in Biscayne Bay; (4) compare density estimates and species diversity based on data from three types of sampling gear.

The study area is located along the western side of the nearshore region of southern Biscayne Bay between Shoal Point (Chicken Key) to the north and Turkey Point to the south. The throw-trap component includes a reference site located in the nearshore area of eastern Biscayne Bay adjacent to Elliott Key. The stratified random sampling design distinguished two geographic zones (Geozone), three salinity zones (Salzone), and two depth zones (Depthzone). Fish and invertebrates were the target species. Animals were weighed for total biomass, then sorted and identified to a practical taxonomic level.

In the statistical models of the samples collected with the roller-frame trawl, latitude and salinity were highly significant in describing density of pink shrimp. Figures 1 through 4 portray the spatial variation in the density of pink shrimp, as sampled by the roller-frame trawl. Shrimp densities were higher in the northern zone than in the southern zone. A notable difference in the zones was that the salinities were moderate to high in the northern zone whereas in the southern zone they were lowest and most variable. However the difference in shrimp densities may reflect an influence of spatial patterns in features other than salinity, for example, bottom habitat. Density increased from August (Figure 1 & 3) to February (Figure 2 & 4) in both years, suggesting recruitment of postlarval shrimp to Biscayne Bay nursery areas during the months of June and July. Caridean shrimp, important in the diet of pink shrimp, were extremely abundant in Biscayne Bay and, by number, the dominant component of the trawl collections. Latitude was a significant factor explaining variation in the density of six fish species. Three species (dusky pipefish, dwarf seahorse, and rainwater killifish) were denser in the north, the hardhead silverside was denser in the south, and two species (hermit crab and tomtate) were densest near Black Point. Salinity was a significant factor explaining variation in the density of ten species (all but dwarf seahorse and hardhead silverside). Eight species were denser at salinities in the lower part of the salinity range in the area sampled by the trawl and two species (dusky pipefish and tomtate) were densest in the middle of the area's salinity range.

The species models with continuous variables suggested that species distributions are influenced by collection date, salinity, and factors in addition to salinity that vary by latitude. Pink shrimp and most fish are more abundant in the inshore area, the unfished zone; but there is no clear suggestion in these data that fishing pressure is the cause of the lower density of most fish species in the deeper waters of the study area. The differences are due more likely to habitat differences than to fishing pressure. Analyses of throw-trap data suggested that the influence of salinity in the distribution and abundance of dominant species in the study area is small compared to that of habitat and other unknown factors.

Research Performance Measure: All objectives were accomplished as planned.

Population Dynamics and Early Life History Processes in Corals

M.J.A. Vermeij (UM/CIMAS); M.W. Miller (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To understand coral population dynamics in relation to environmental variability through both space and time so as to lead to better management strategies for the recovery of Caribbean corals reefs especially those in the Florida Keys.
- **Strategy:** To study the early life history processes in corals and the impact on their survival.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

We carried out a laboratory study of the early life-history dynamics of several major Caribbean species, in particular *Montastraea faveolata*, *Acropora palmata*, *Siderastrea radians* and *Agaricia humilis*. Survival and appropriate habitat choice of a coral planula are dependent to a degree on its earlier experiences in the plankton stage. Coral planulae show behavioral responses during the presettlement period indicating that their survival and dispersal may be determined in part by factors other than those that are purely stochastic (e.g. currents, predation). While it is premature to speculate on the implications of this laboratory behavior by extrapolating these results to the field, the potential importance of presettlement processes should nonetheless be carefully considered as an additional important factor in coral population dynamics.

In addition, increased habitat quality (in terms of the presence of “open” space and coverage by crustose coralline algae) and adult cover improve local settlement rates. The degree to which these factors affect local settlement rates is however variable through time and disappears during extreme disturbance events such as the 2004 Florida hurricanes. During the hurricanes extreme sand scour eradicated nearly all juvenile and adult coral colonies thereby “resetting” local colonization trajectories. The degree to which population densities decreased depended on local (i.e. at a 10m² scale) sedimentation rates.

In contrast to recruit survival, juvenile growth rates were highly variable and unrelated to benthic community structure, at least at the scale of this study. Competing benthic organisms affected coral recruitment success through space preemption (mainly by macroalgae) or recruit overgrowth (mainly by sponges).

The results highlight the small spatial scale (mm-cm) at which the processes occur that are responsible for the success or failure of recruitment and they emphasize the need to include such small scale observations in studies of coral early life-phase dynamics.

Research Performance Measure: All research goals were met.

Simulation and Analysis of Monthly Salinity Patterns Resulting from Alternative Configurations of the Southern Golden Gate Estates Restoration Project

J.D. Wang (UM/RSMAS); J. Browder (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To evaluate receiving-body salinity patterns and fish abundance resulting from alternate runoff scenarios into Faka Union Bay.
- **Strategy:** To develop a hydrodynamic and salinity model that simulates salinity patterns from alternative design plans of the Southern Golden Gate Estates Restoration Project, part of the South Florida Restoration Program.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics
- **Theme 3:** Regional Coastal Ecosystem Processes
- **Theme 4:** Human Interactions with the Environment

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary

A number of plans have been proposed for increasing fresh water discharges into Faka Union Bay; these would result in different levels of inputs. The Bay is an important estuarine ecosystem supporting juvenile fishes. Its management and restoration will have important effects on the recreational and commercial fisheries in the Ten Thousand Islands area on the southwest Florida coast. We use a numerical model that predicts bay-wide salinities based on runoff volume rates and prescribed Bay opening salinities using the established relationships. We examine the relationships between freshwater inflow and salinity and update a numerical finite element hydrodynamic and salinity prediction model to reflect the change in these relationships from the 1980s to recent years. Model results for a range of discharge values are summarized for biological assessment by determining the area of the Bay (as a percentage) contained within every 1 psu salinity band as a function of salinity (abscissa) and discharge (ordinate) (Fig. 1).

Under the direction of the South Florida Water Management District, we simulated an average rainfall year (1994) with the numerical model and obtained monthly salinity regimes for existing conditions and for five CERP restoration scenarios: 2050 without project, natural system, Alternative 6, 12, and 3D. We also simulated existing conditions and two scenarios: for the natural system, and Alternative 3D for a 12-year period (from 1989-2000) to include effects of interannual rainfall variability.

To determine abundance of several fish species, we worked with Joan Browder, NOAA/SEFSC. We used

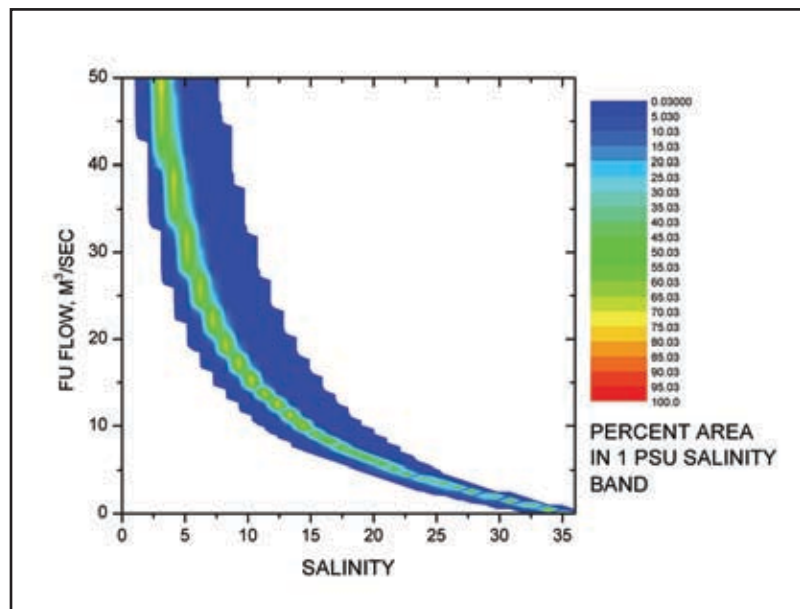


Figure 1: Percent Bay bottom area within 1 psu salinity range as function of average monthly runoff and salinity.

her previously-derived fisheries statistical models and linked them to our computed monthly time series of Bay bottom areas within salinity bands (aggregated to 3 psu ranges). We find that three of four species (bay anchovy, silver perch, and pinfish) are expected to become more abundant in Faka Union Bay when flows and salinity patterns are made more similar to those expected from a natural hydrologic system (that is, the system that existed before the construction of canals and levees). All four species spend all or a part of their time in estuaries, where salinities are less than sea water strength (35 psu) because of the influence of fresh water. In general our model predicts the greatest gains in abundance with the “natural system” condition and those restoration design alternatives that most closely mimic the freshwater runoff volume and timing of the natural system. As a management tool, our model suggests goals for restoration efforts and can help guide future improvements with quantitative performance measures in an adaptive management mode.

Research Performance Measure: We attained our primary objective: to develop an hydrological model that can be used as an ecosystem restoration management tool for Faka Union Bay.

Spectral Optimization in Case 2 Waters

K.J. Voss and H.R. Gordon (UM/Dept. of Physics)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To retrieve atmosphere and ocean properties in the near coastal environment for use in ocean color remote sensing.
- **Strategy:** To develop a coupled atmosphere-ocean algorithm with specific application to areas such as the Chesapeake Bay.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management;

Research Summary:

Coastal waters are an important contributor to the overall productivity of the ocean, but it is very difficult to measure the properties of these waters from space due to confounding signals in this dynamic environment. Our objective is to produce an algorithm that reliably retrieves accurate ocean color information (such as chlorophyll concentration, dissolved organic matter content, backscattering from particulates) in shallow water and in the presence of highly varying aerosols, some of which may be absorbing solar radiation. Prior to the beginning of this project we used the standard algorithm on 20 different days of SeaWiFS imagery; the algorithm displayed poor performance in case 2 inland waters and only partial performance in case 2 coastal waters. We are developing the Spectral Optimization Algorithm (SOA) as an alternative to the standard atmospheric correction algorithm. The SOA, when fully implemented, will be capable of recognizing the presence of difficult coastal waters and performing bio-optical retrievals in these waters. Earlier work modified SOA to incorporate atmospheric corrections and enable the subsequent bio-optical retrievals in case 2 waters. Since then the algorithm has been further developed with considerable improvement in case 2 waters. We are currently investigating how well these modifications work with *in situ* measurements. The final performance measure will be an algorithm that enables retrievals without failure and produces values that agree with in-situ data. We currently have a tuned data set from the Chesapeake with which we are doing comparisons of the in-situ measured water properties with derived properties from the SOA.

Research Performance Measure: All research objectives are currently being met on schedule.

Effect of Salinity and Temperature on the Sediment/Water Exchange of Phosphorous: Predicting Response of Phosphorous Regional Model for South Florida Coastal Seas

V. Kourafalou (UM/RSMAS); G. Goni (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To develop a regional circulation model around South Florida and regional waters that can be used for environmental assessments and planning in conjunction with the South Florida Everglades Restoration.
- **Strategy:** To develop a regional high resolution model (the Florida Straits and the southeastern Gulf of Mexico) that has sufficiently detailed bathymetry to resolve the shallow areas; to embed this model within a larger scale model, which has coarser resolution and bathymetry, to ensure the proper linkage between coastal and oceanic flows and between the South Florida ecosystems and remote, upstream sources of nutrient-rich waters.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes
- **Theme 6:** Integrated Ocean Observations (secondary)

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

We have developed a comprehensive, high resolution, numerical model of circulation and transport dynamics for the seas around South Florida. The regional South Florida model includes ecologically sensitive shallow areas (Florida Bay, the Dry Tortugas Ecological Reserve and the Florida Keys Marine Sanctuary), shelf areas (the relatively broad southwest Florida shelf and the narrow shelf along the Atlantic side of the Florida Keys) and deep areas (Straits of Florida). The motivation for the development of the regional model was based on results from long term observational monitoring around South Florida, that have provided concrete evidence that the area's distinct marine environments are strongly inter-connected by circulation and biochemical exchange processes on a regional scale, while oceanic boundary currents connect them to remote ecosystems of the Gulf of Mexico and the Caribbean. The Regional model addresses these connections by being nested within a larger scale model of the North Atlantic and Gulf of Mexico. Thus, the South Florida coastal areas receive the proper connections with the oceanic flows that surround them.

The Regional model has been named SoFLA-HYCOM (for South Florida HYCOM), as it is an adaptation of the state-of-the-art Hybrid Coordinate Ocean Model (HYCOM). A particular advantage of HYCOM-based models is that they incorporate a unique hybrid vertical coordinate system that has the ability to adjust itself and thus it offers great advantages for areas that convert from deep to shelf regions, such as the Straits of Florida. The coordinate system is isopycnal in the stratified open ocean, terrain-following in the shallow coastal regions, and z-level in the mixed layer and/or unstratified seas.

The SoFLA-HYCOM model has two particular features that allow realistic numerical simulations for the coastal seas surrounding South Florida: (a) it receives information from a larger scale model, so it “knows” about fundamental South Florida processes such as the variability of the Loop Current/Florida Current (LC/FC) system, the eddies that travel along the LC/FC front, the inflow of low salinity (and nutrient-rich) waters of remote river origin (west Florida shelf rivers and the Mississippi River); (b) it employs detailed shallow shelf bathymetry, derived from a digital terrain data set with 2' resolution (NAVO-NRL DBDB2 data set) and further refined in the shallow coastal areas. Simulations with the SoFLA-HYCOM are currently in progress, both with long-term (climatological) atmospheric forcing and with realistic forcing for particular years. Processes that are known from observations have been reproduced in the numerical simulations, such as the propagation of eddies along the FC front, as well as the formation of wind-driven southwestward flow along the Atlantic Keys

shelf, which agrees well with drifter trajectories and wind-driven events recorded in moored current meters. An example of modeled surface temperature and currents is shown in Fig. 1, where a frontal eddy that was formed in the Dry Tortugas moves along the Straits of Florida where it elongates and is “squeezed” between the Florida Current and the Florida Keys. The model resolves the horizontal temperature contrasts between cold shallow areas in and around Florida Bay, warm FC and cool eddy waters that are circulating cyclonically inside the eddy. Clear intrusions toward the Keys passages of warmer filaments within the eddy can be seen; this implies a delivery mechanism to the Florida Keys of nutrients and larvae (that were “trapped” in the eddy) from remote upstream areas such as the Dry Tortugas.

The SoFLA-HYCOM is an important component of physical and biogeochemical research for the diverse South Florida ecosystems. Preliminary tests on coupling with a larvae transport biological model have taken place and coupling with a shallow water model of Florida Bay (which is being developed as part of the Everglades Restoration Project) is the focus of a separate CIMAS project (see this Report).

Research Performance Measure: The major objectives - the development of the model and the performed simulations - have been satisfactorily achieved.

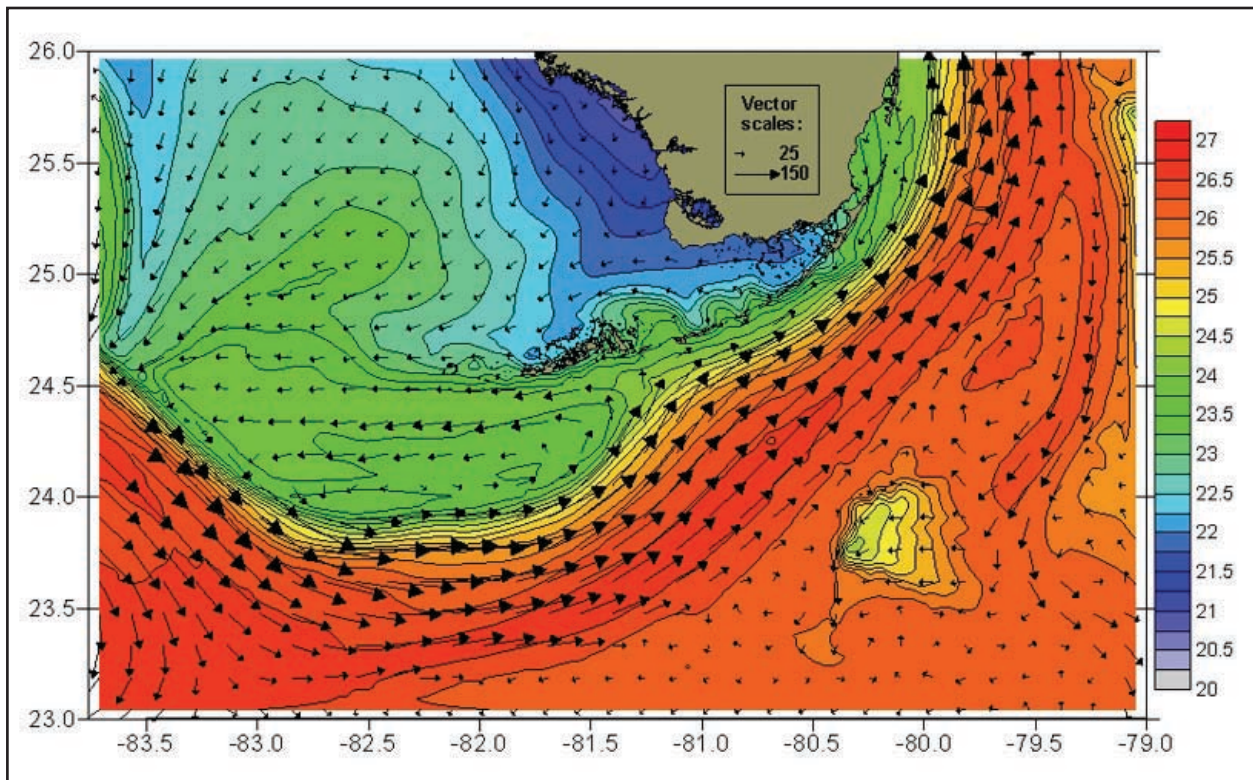


Fig. 1. A snapshot of near-surface temperature and current (every 3rd vector plotted; cm/s) from the SoFLA-HYCOM model showing details of interaction between the passage of a mesoscale frontal eddy and the shallow topography of the Florida Keys.

Atmospheric and Ocean Modeling Support for Boundary Inputs to the Florida Bay Hydrodynamic Model

V. Kourafalou (UM/RSMAS); G. Goni (NOAA/AOML).

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To simulate the interaction between the coastal flows around Florida Bay and the surrounding oceanic flows; to model salinity variability and eddy structures throughout the region.
- **Strategy:** To use a nesting approach where the regional model performs simulations that provide boundary inputs to the Florida Bay hydrodynamic model which is being developed by the South Florida Water Management District, as part of the South Florida - Everglades Restoration Project.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes
- **Theme 6:** Integrated Ocean Observations (secondary)

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The Florida Bay Hydrodynamic Model is being developed by the South Florida Management District to fulfill numerical simulations and restoration scenarios as part of the Everglades Restoration Project. Florida Bay, a crucial part of the South Florida ecosystem, is linked to adjacent coastal ecosystems (such as the Florida Keys Reef Tract) and to neighboring shelf and deep sea areas (such as the southwest Florida shelf, the Gulf of Mexico and the Straits of Florida). Proper numerical simulations for Florida Bay need to include these linkages. This can only be achieved through the specification of flows and oceanographic parameters at the boundaries of the Florida Bay model. The present study focuses on the development of such dynamical links, by developing the appropriate regional model that will connect Florida Bay with the coastal and oceanic regions around South Florida.

The SoFLA-HYCOM model (South Florida Hybrid Coordinate Ocean Model) is the Regional model for South Florida coastal seas. It has been developed specifically as a connection between South Florida's shallow coastal environments and the adjacent deep areas in the Straits of Florida and the Gulf of Mexico. A particular application of the SoFLA-HYCOM is to provide boundary conditions and atmospheric inputs for the Florida Bay model. To ensure proper connection with the Gulf of Mexico and the Straits of Florida (as well as the global circulation around them), the SoFLA-HYCOM is nested within the North Atlantic HYCOM that includes the Gulf of Mexico and the Caribbean, so that information on large scale flows enters through its boundaries. Therefore, the regional model acts as a crucial intermediate step from the large to the coastal scale.

We performed numerical simulations that confirm the data-based hypothesis that Florida Bay is subject to intense interactions with the southwest Florida shelf and with the Florida Keys and Straits of Florida (through flows in the Keys passages). Experiments with tracers released in the model in the Dry Tortugas area demonstrate that eddies provide an important mechanism for the retention of nutrients and larvae and for the subsequent release toward the Florida Keys Reef Tract, through eddy shredding upon interaction with the rough Keys topography. Pathways that reach Florida Bay through the Keys passages have been demonstrated.

Changes in salinity around Florida Bay have been simulated and associated with evaporation/precipitation and with changes in river flows (and associated buoyancy-driven circulation) from the neighboring rivers. An example is shown in Fig. 1, where the salinity of Florida Bay is influenced by the southwest Florida shelf rivers during periods of northerly winds, while light winds allow the riverine low salinity waters to escape toward north, bearing no influence on Florida Bay. The influence of remote sources of low-salinity from as far as the Mississippi River has also been shown.

The coupling between the SoFLA-HYCOM regional model and the Florida Bay coastal model forms the basis of a model system that can be used for the study of all hydrodynamic processes that affect the South Florida ecosystem dynamics. This system can be expanded for the study of larvae and nutrient transport, water quality issues and fisheries management.

Research Performance Measure: All modeling objectives are being achieved on schedule.

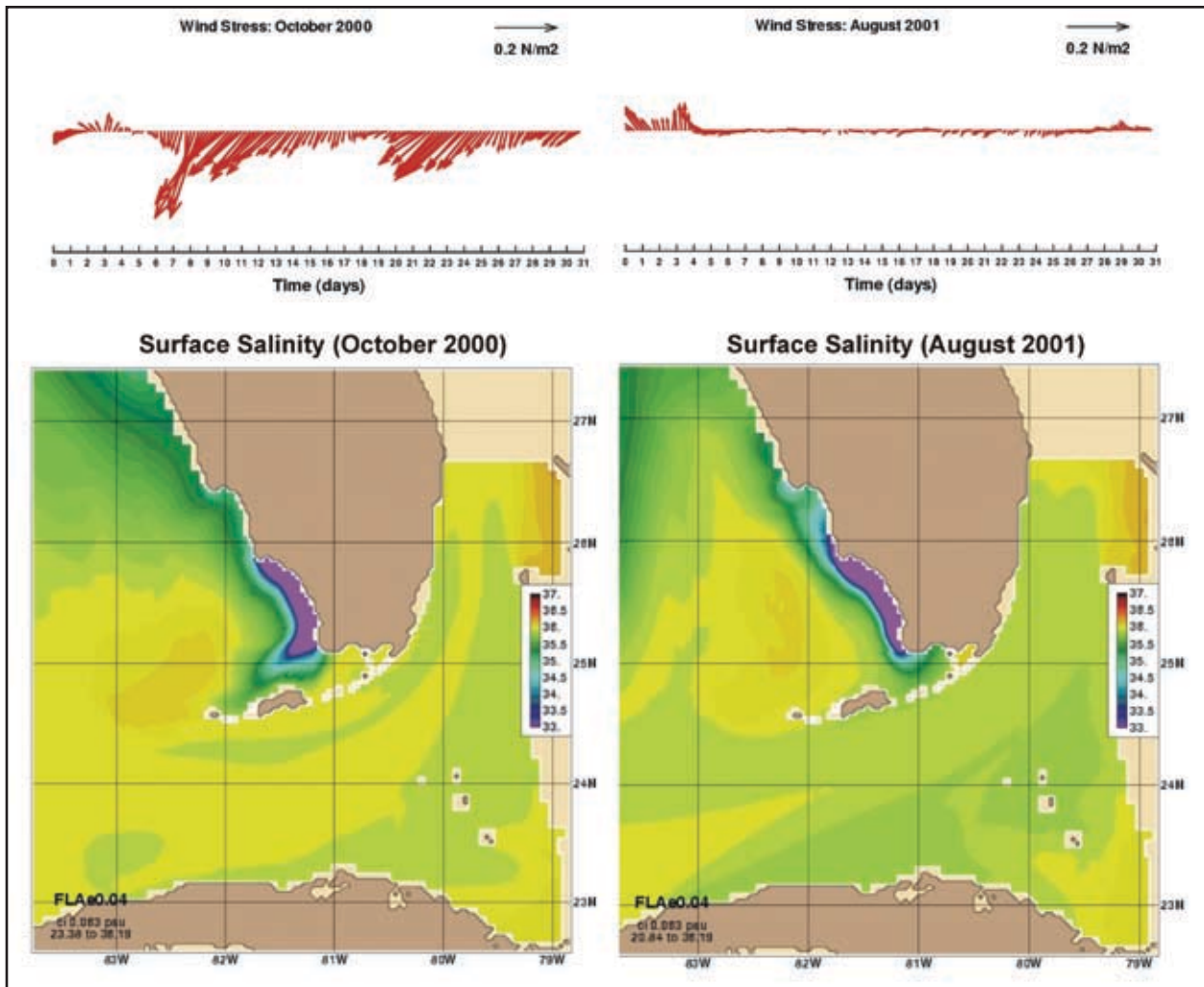


Fig. 1: SoFLA-HYCOM surface salinity during periods of light winds (left panel) and strong northerly winds (right panel); wind vectors are from the location marked by red circle. The low-salinity waters from the southwest Florida shelf rivers are advected toward north (bearing little no influence on Florida Bay) and south (modifying the hypersaline conditions in Florida Bay, respectively).

SFP 2004: Transport and Exchange of Florida Bay Interior Waters

N. Melo (UM/CIMAS); T.N. Lee (UM/RSMAS); E. Johns and R. Smith (NOAA/AOML);
N. Smith (Harbor Branch Oceanographic Institution)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To understand the circulation and exchange processes that regulate the residence times and flushing rates within interior basins of Florida Bay and to improve prediction of the effects of modifying fresh water supply to the Everglades as part of Everglades restoration plans.
- **Strategy:** To make direct measurement of salinity variability and water exchange within the major sub-regions of Florida Bay during wet and dry seasons.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

The objectives of this project are to identify the primary physical processes controlling water renewal and salinity variability within the inner basins of Florida Bay and the interactions with connecting regions of the southwest Florida shelf and Florida Keys. This information is needed to aid calibration and verification of hydrodynamic models for prediction of the impact of future changes in water deliveries to the Everglades and Florida Bay as part of South Florida - Everglades restoration projects.

Our most recent efforts involve a concentrated approach that combines the observational resources of HBOI, AOML and RSMAS to focus on the western basins of Florida Bay. By combining resources we are able to directly measure the volume and salt transports through all the major channels to the Twin Key and Rabbit Key western basins while making detailed surveys of changes in salinity patterns over the 2004 dry season and 2005 wet season (see: Long-Term Measurement of Physical, Chemical, and Biological Water Column Properties in the South Florida Coastal Ecosystem). Circulation within the basins was measured with shallow water drifters that transmit GPS positions via satellite.

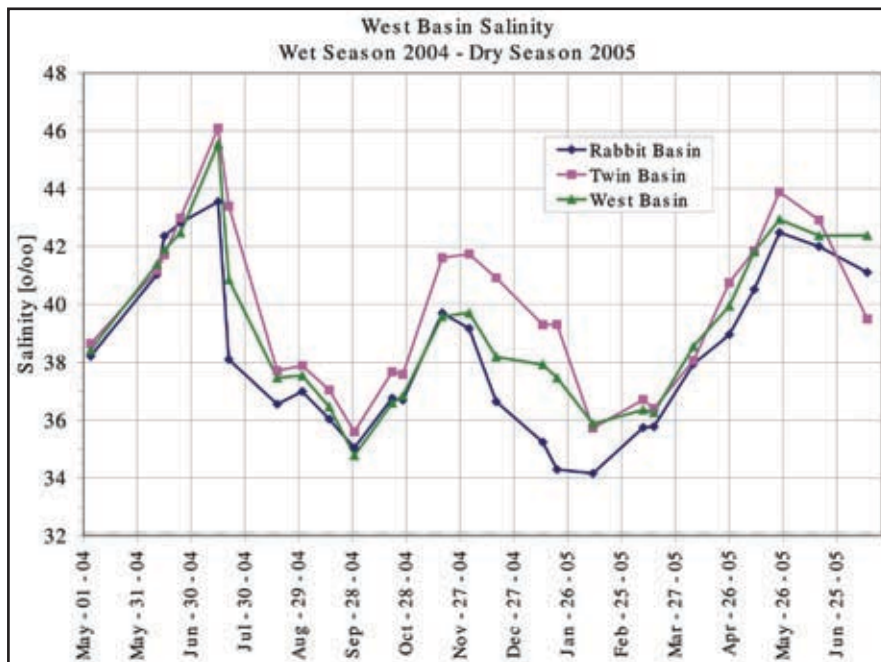
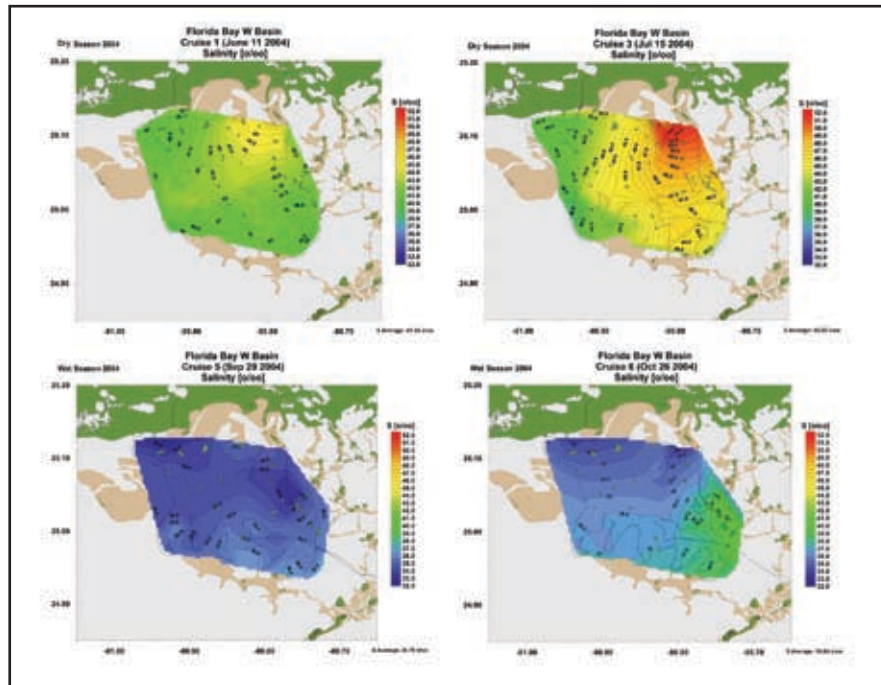
We find that water renewal in the north-central sub-region of Florida Bay is strongly regulated by local wind forcing. Ground water input to the bay is relatively unimportant. Hypersalinity conditions develop through the combined effects of reduced fresh water inputs during the dry season combined with weak basin water renewal rates.

Representative wet and dry season salinity patterns are shown in Figure 1 and a time series of basin average salinity in Figure 2. Hypersalinity developed in the north-central sub-region and reached a maximum in Whipray basin at the end of the dry season (July 15). High salinity extended southward from Whipray basin into Twin Key basin. This appears to be the preferred exchange route for expansion of the high salinity area to the south. We had previously found this exchange to be largely due to wind-driven transports with a seasonal mean outflow in the deeper channels balanced by inflow over the shallow western banks. These processes resulted in a residence time of 6 to 12 months for Whipray basin.

The start of the wet season began with the sudden freshening of the western and north-central regions in the second half of July (Figures 1 and 2). The freshening is attributed to exchanges with low-salinity Gulf river discharge along the western boundary of Florida Bay combined with direct rainfall. Time series of mean basin salinity (Figure 2) shows that a secondary maximum developed in November from an unusual fall drought following the active 2004 hurricane season. Minimum mean basin salinity occurred in February 2005, again largely driven by exchanges with Gulf riverine waters. We continue to analyze these data to better understand

and model physical processes in Florida Bay and their impact on surrounding waters of south Florida.

Research Performance Measure: We are satisfactorily meeting our *objectives*: to directly measure transport and salinity variability in Florida Bay basins.



Long-Term Measurement of Physical, Chemical, and Biological Water Column Properties in the South Florida Coastal Ecosystem

C. Kelble, G. Rawson, N. Melo and B. Kates (UM/CIMAS); T. N. Lee, (UM/RSMAS); P. Ortner, L. Johns, R. Smith and J.-Z. Zhang (NOAA/AOML); C. Hu (USF)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To determine the circulation and water property patterns within Florida Bay and surrounding coastal waters on “event” to inter-annual time scale; to quantify the effect of singular climactic events, such as tropical cyclones and *El Niño*, on the water column properties in Florida Bay.
- **Strategy:** To carry out regular monthly and supplemental event-focused monitoring cruises in conjunction with a moored instrument array and targeted drifter releases.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

Water properties in Florida Bay and Biscayne Bay can change dramatically depending on a wide range of factors including weather (e.g., storms), runoff from land, and variations in currents in adjacent coastal waters. To better understand the factors affecting these changes we make high resolution surveys of Florida Bay and Biscayne Bay on a monthly basis or following “events”, such as hurricanes. On these surveys, we continuously measure salinity, temperature, chlorophyll, percent light transmittance, and chromophoric dissolved organic matter (CDOM) utilizing a flow-through water system. Periodically, we stop at discrete sampling stations for more extensive measurements of water column properties including light attenuation, chlorophyll *a*, total suspended solids (TSS), dissolved inorganic nutrients, and we take a profile of temperature and salinity throughout the depth of the water column. Contour maps are produced from the cruise data and posted in near real time on the worldwide web at <http://www.aoml.noaa.gov/sfp/> thereby permitting timely access of our results by the South Florida Ecosystem Restoration (SFER) scientific and management communities. Figure 1 depicts the two salinity extremes observed in Florida Bay with the top panel showing an estuarine bay after the passing of hurricane Irene and the bottom panel showing Florida Bay at its most hypersaline during our study period.

In addition, we conduct bimonthly, large-vessel surveys on which we measure similar parameters in the near-shore waters of South Florida from Ft. Myers to the Dry Tortugas and along the Florida Keys National Marine Sanctuary (FKNMS) reef

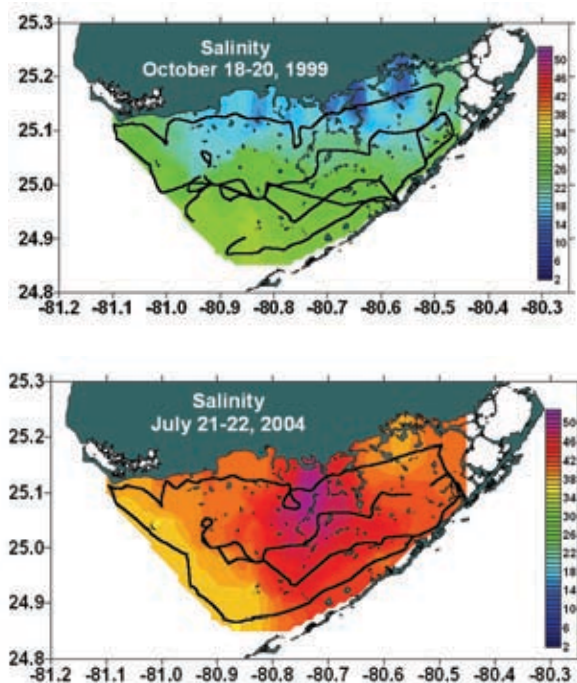


Figure 1. Contour maps of the salinity extremes of Florida Bay depicting the bay at its freshest just after the passing of hurricane Irene on October 15, 1999 and at its saltiest in July of 2004 after a period of anomalously low rainfall over South Florida.

tract northward to Miami. Acoustic doppler current profiler (ADCP) surveys are made during the large-vessel cruises in an effort to document eddy development and the interaction between the Gulf Stream with FKNMS coastal waters. We also make bi-monthly releases of surface drifters in the Dry Tortugas, just offshore of Charlotte Harbor, and at the mouth of the Shark River to document current trajectories in these areas. These data are also made available on the project website in near real-time. Furthermore, a moored instrument array is maintained to continuously measure temperature, salinity, and current trajectories along the southern SW Florida shelf and along the perimeter of Florida Bay. All project data can be accessed at www.aoml.noaa.gov/sfp/.

Research Performance Measure: The circulation and water property patterns within Florida Bay and surrounding coastal waters have been determined on “event” to inter-annual time scales. The underlying causes for the observed water property patterns have been identified and quantified, including singular climactic events, such as *El Niño* and tropical cyclones.

Real-time Currents and Water Quality Monitoring in the Florida Keys National Marine Sanctuary (FKNMS)

N. Melo, C. Kelble, H. Guarin, B. Kates and G. Rawson (UM/CIMAS);

T.N. Lee (UM/RSMAS); E. Johns, P.B. Ortner, J.C. Hendee, R. Smith,

S. Cummings, D. Bitterman and U. Rivero (NOAA/AOML); C. Hu (Univ. S. Florida)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To monitor and understand the coastal circulation in and around the FKNMS on tidal to interannual as well as “event” time scales.
- **Strategy:** To maintain, upgrade, and expand the existing network of real-time oceanographic observations in the FKNMS and adjacent coastal waters, and use the resulting real-time data in conjunction with other available oceanographic data to achieve the above research objectives.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management
- **Goal 3:** Serve Society’s Needs for Weather and Water Information (*secondary*)

Research Summary:

The operational part of this project focuses on the construction, deployment, and testing of the necessary instrumentation needed for real-time data collection in the Florida Keys. Stations in the network which are currently operating in real-time include Looe Key and Moser Channel (see station web pages at www.looekeydata.net and www.aoml.noaa.gov/sfcoo/7MB, respectively). A new station is being installed at the NOAA/UNCW “Aquarius” underwater laboratory in Key Largo, FL; it is scheduled to go on-line by Fall 2005. The Aquarius station will include real-time current and water quality instrumentation, a dissolved oxygen sensor, and a directional wave spectra acoustic Doppler current profiler (ADCP). We continue to improve our existing mooring and array designs, and we are experimenting with cheaper, faster, and more reliable ways of telemetering data back to our laboratory.

The scientific part of the project focuses on collecting and quality-controlling the real-time data, incorporating additional non-real-time data from other projects into the analysis, and providing web-based presentations of the results. Ancillary data include shipboard observations, data from moored real-time and non-real-time moorings around the region, real-time trajectories of satellite-tracked surface drifters, and satellite remote sensing.

Scientific research results to date include observations of the variability of the flow through the Keys passages, showing that real-time wind and sea level height data can give an indication of the magnitude of these flows. Furthermore, real-time observations of biological/chemical parameters such as chlorophyll and light transmittance, coupled with remote sensing of ocean color from satellites, can be used to assess the water quality of these flows and their potential effect on the coral reefs of the FKNMS.

Research Performance Measure: All operational project objectives as listed in the NOAA South Florida Program (SFP 2004) proposal are being met, with the exception of the planned upgrade to the CMAN/Seakeys station located in the Dry Tortugas. This station was destroyed by a hurricane in 2004 and has not yet been redeployed by the NOAA’s National Data Buoy Center (NDBC). All scientific objectives are also being met, and we continue to develop our understanding of how to monitor the highly variable marine environment of the FKNMS.

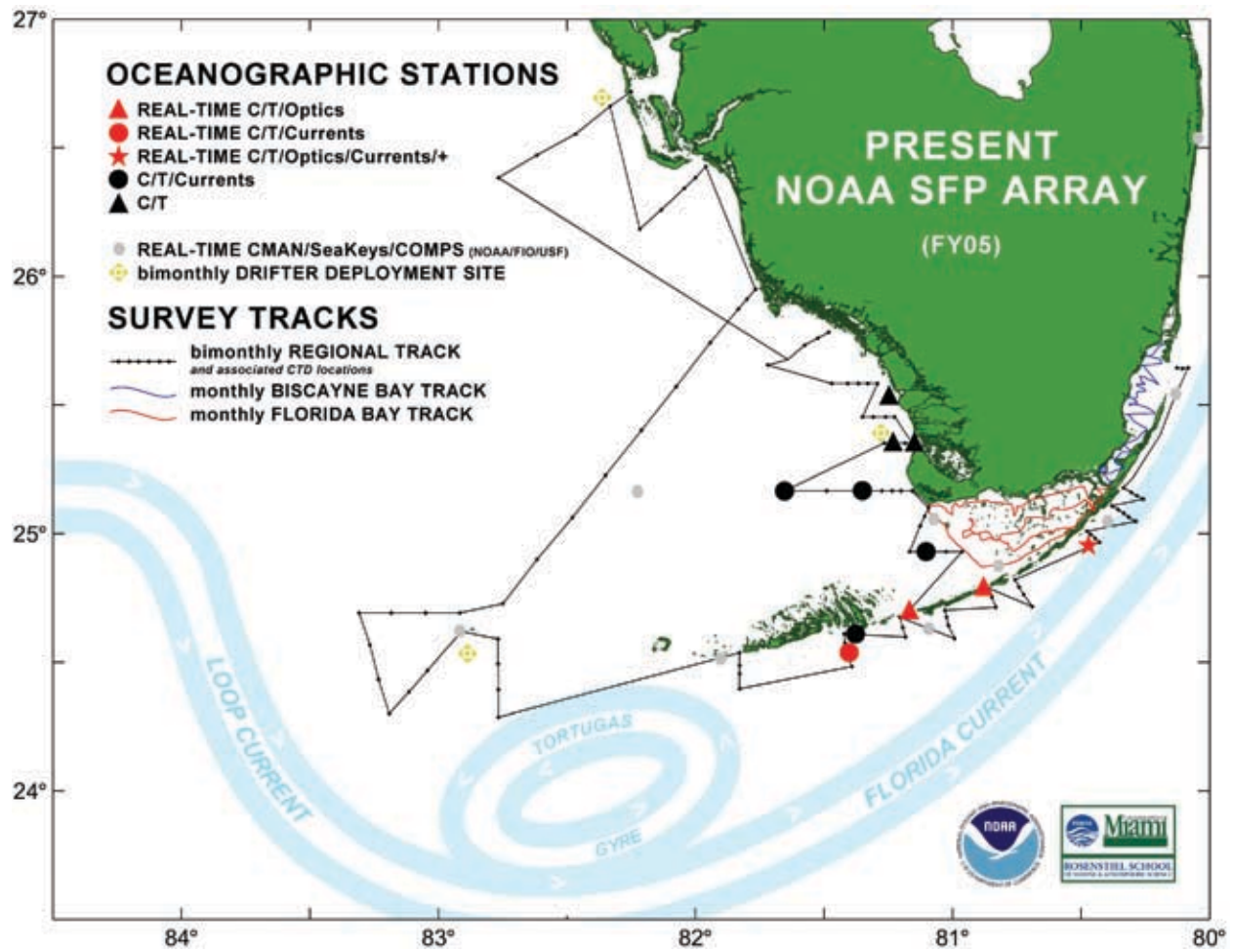


Figure 1 shows the present South Florida Program configuration, with the real-time stations shown in red. Results from the real-time array are interpreted in conjunction with data from shipboard surveys, non-real-time moorings, and satellite-tracked surface drifter deployments as indicated.

Determination of Genetically Distinct Subgroups and Contaminant Body Burdens of Resident Bottlenose Dolphin (*Tursiops truncatus*) within Biscayne Bay, FL

J. Litz, M. Gaines, and J. Wicker (UM/CIMAS); L. Fieber, and P. Walsh (UM/RSMAS);
L. Garrison, J. Kucklick, P. Rosel, A. Martinez, and J. Contillo (NOAA/SEFSC);
C. Hughes (Florida Atlantic University)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To define the genetic structure of resident bottlenose dolphins within Biscayne Bay using molecular genetic techniques; to evaluate the current profiles of persistent organic pollutants in a model organism, the bottlenose dolphin, in Biscayne Bay.
- **Strategy:** To use mitochondrial DNA haplotypes and genotypes from 14 microsatellite loci to examine genetic structure within Biscayne Bay; to analyze blubber samples from Biscayne Bay dolphins for persistent organic pollutants using gas chromatography/mass spectrometry.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

Bottlenose dolphins are year-round residents in Biscayne Bay, Florida. This project is using genetic techniques to determine if the resident bottlenose dolphin population within Biscayne Bay consists of one breeding stock or several distinct breeding stocks of dolphins. By integrating these genetic data with photo-identification data from NOAA SEFSC, we obtain a clearer picture of the overall social and stock structure of this dolphin community. In addition, dolphins have previously been shown to bioaccumulate persistent organic pollutants (POPs) in their blubber layer, such as PCB's, and DDT's. Because of these characteristics, bottlenose dolphins can be used as biological indicators of the health of their habitat and can be used to compare contaminant levels from different geographical areas. This project is collecting baseline data on the types of compounds stored in the blubber of resident dolphins and comparing the results to those found in dolphins in other areas of Florida. The POP levels found will be compared among dolphins from Biscayne Bay to determine if animals are limiting their feeding activities to different areas of the bay.

Following approved animal techniques and with the appropriate permits, we used a remote biopsy sampling procedure to obtain skin and blubber samples. This procedure consists of firing specially designed darts with biopsy sampling heads from a modified rifle. The samples obtained generally consist of a layer of skin and core of blubber that are roughly 1 cm in diameter and weigh between 0.5 and 1 gram. Photographs were taken of the dorsal fin of each animal sampled to match to the NOAA Fisheries photo-identification catalogue. This allows sighting histories of individuals to be linked with the tissue samples. The dolphins' reactions to biopsy sampling were carefully observed and recorded as required by the Marine Mammal Protection Act. Although we do not expect any long-term effects on the animals caused by the sampling, observations of the biopsy wound and behavior are recorded when previously sampled animals are sighted in subsequent surveys.

Genetic analyses have been conducted at the University of Miami and the NOAA Marine Mammal Molecular Genetics Laboratory in Lafayette, LA. Skin samples were genotyped to determine gender, sequenced at the mitochondrial DNA control region, and genotyped at 14 nuclear loci. Contaminants analysis was completed at the NOAA, NIST laboratory in Charleston, SC. Blubber samples were analyzed by gas chromatography/mass spectrometry for 68 polychlorinated biphenyl (PCB) congeners, six polybrominated diphenyl ether (PBDE) congeners, and organochlorine pesticides including DDT and metabolites, chlordanes, dieldrin, and mirex. The genetics and contaminants data are currently being analyzed and the results compiled. Preliminary data analyses indicate variance in POP concentrations between samples is largely explained by geographic location within

Biscayne Bay. Animals with sighting histories primarily in the northern, more developed, area appear to have higher POP concentrations than animals with sighting histories in the southern, less developed, area.

Research Performance Measure: The program is currently underway and all objectives are being met on schedule. All of the sample collection and laboratory analysis for this project has been completed. The statistics and data analyses are currently ongoing

Biscayne Bay Bottlenose Dolphin Skin and Blubber Samples

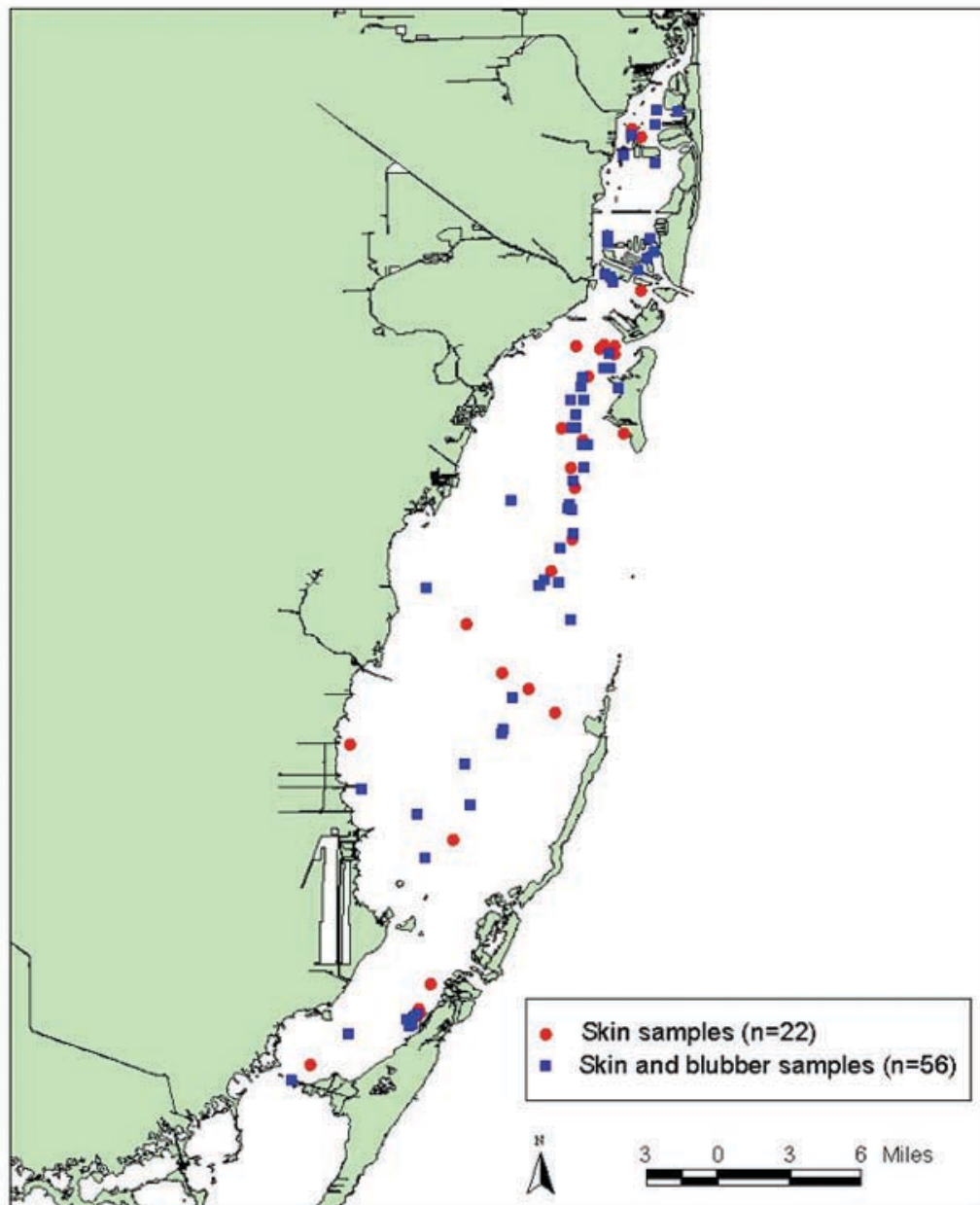


Fig. 1: Skin and blubber biopsy samples collected from resident bottlenose dolphins in Biscayne Bay, Florida.

Population Dynamics and Early Life History Processes in Corals

M.J.A. Vermeij (UM/CIMAS); M.W. Miller (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To understand coral population dynamics in relation to environmental variability through both space and time so as to lead to better management strategies for the recovery of Caribbean corals reefs especially those in the Florida Keys.
- **Strategy:** To study the early life history processes in corals and the impact on their survival.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

We carried out a laboratory study of the early life-history dynamics of several major Caribbean species, in particular *Montastraea faveolata*, *Acropora palmata*, *Siderastrea radians* and *Agaricia humilis*. Survival and appropriate habitat choice of a coral planula are dependent to a degree on its earlier experiences in the plankton stage. Coral planulae show behavioral responses during the presettlement period indicating that their survival and dispersal may be determined in part by factors other than those that are purely stochastic (e.g. currents, predation). While it is premature to speculate on the implications of this laboratory behavior by extrapolating these results to the field, the potential importance of presettlement processes should nonetheless be carefully considered as an additional important factor in coral population dynamics.

In addition, increased habitat quality (in terms of the presence of “open” space and coverage by crustose coralline algae) and adult cover improve local settlement rates. The degree to which these factors affect local settlement rates is however variable through time and disappears during extreme disturbance events such as the 2004 Florida hurricanes. During the hurricanes extreme sand scour eradicated nearly all juvenile and adult coral colonies thereby “resetting” local colonization trajectories. The degree to which population densities decreased depended on local (i.e. at a 10m² scale) sedimentation rates.

In contrast to recruit survival, juvenile growth rates were highly variable and unrelated to benthic community structure, at least at the scale of this study. Competing benthic organisms affected coral recruitment success through space preemption (mainly by macroalgae) or

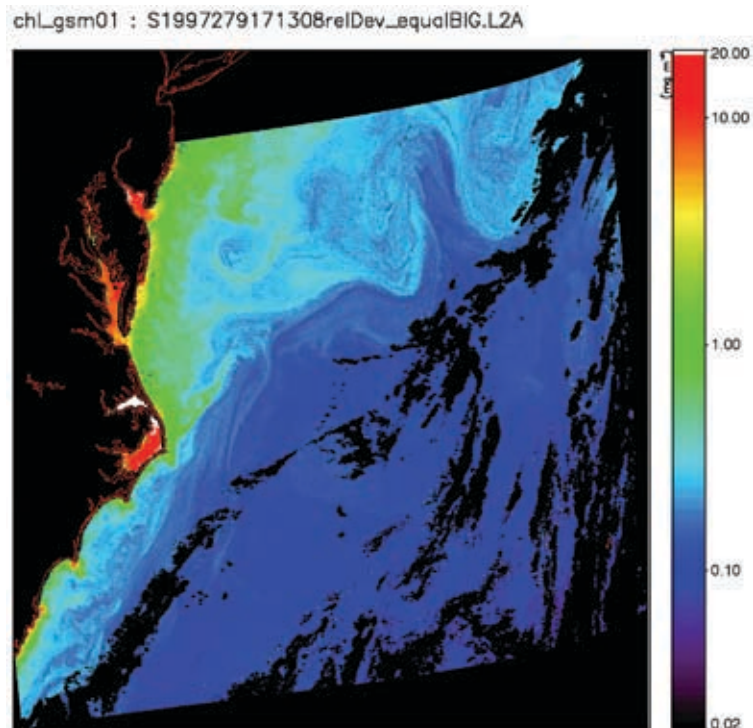


Figure 1: NASA SeaWiFS data mid-west Atlantic; day 297, 1997 Chlorophyll concentration (C) mg m⁻³ Large black groups = cloud; isolated black pixels (C = 0.02 mg m⁻³) or white pixels (C = -20 mg m⁻³) implies possible algorithm failure.

Simulation and Analysis of Monthly Salinity Patterns Resulting from Alternative Configurations of the Southern Golden Gate Estates Restoration Project

J.D. Wang (UM/RSMAS); J. Browder (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To evaluate receiving-body salinity patterns and fish abundance resulting from alternate runoff scenarios into Faka Union Bay.
- **Strategy:** To develop a hydrodynamic and salinity model that simulates salinity patterns from alternative design plans of the Southern Golden Gate Estates Restoration Project, part of the South Florida Restoration Program.

CIMAS Research Theme:

- **Theme 2:** Fisheries Dynamics
- **Theme 3:** Regional Coastal Ecosystem Processes
- **Theme 4:** Human Interactions with the Environment

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary

A number of plans have been proposed for increasing fresh water discharges into Faka Union Bay; these would result in different levels of inputs. The Bay is an important estuarine ecosystem supporting juvenile fishes. Its management and restoration will have important effects on the recreational and commercial fisheries in the Ten Thousand Islands area on the southwest Florida coast. We use a numerical model that predicts bay-wide salinities based on runoff volume rates and prescribed Bay opening salinities using the established relationships. We examine the relationships between freshwater inflow and salinity and update a numerical finite element hydrodynamic and salinity prediction model to reflect the change in these relationships from the 1980s to recent years. Model results for a range of discharge values are summarized for biological assessment by determining the area of the Bay (as a percentage) contained within every 1 psu salinity band as a function of salinity (abscissa) and discharge (ordinate) (Fig. 1).

Under the direction of the South Florida Water Management District, we simulated an average rainfall year (1994) with the numerical model and obtained monthly salinity regimes for existing conditions and for five CERP restoration scenarios: 2050 without project, natural system, Alternative 6, 12, and 3D. We also simulated existing conditions and two scenarios: for the natural system, and Alternative 3D for a 12-year period (from 1989-2000) to include effects of interannual rainfall variability.

To determine abundance of several fish species, we worked with Joan Browder, NOAA/SEFSC. We used her previously-derived fisheries statistical models and linked them to our computed monthly time series of Bay bottom areas within salinity bands (aggregated to 3 psu ranges). We find that three of four species (bay anchovy, silver perch, and pinfish) are expected to become more abundant in Faka Union Bay when flows and salinity patterns are made more similar to those expected from a natural hydrologic system (that is, the system that existed before the construction of canals and levees). All four species spend all or a part of their time in estuaries, where salinities are less than sea water strength (35 psu) because of the influence of fresh water. In general our model predicts the greatest gains in abundance with the “natural system” condition and those restoration design alternatives that most closely mimic the freshwater runoff volume and timing of the natural system. As a management tool, our model suggests goals for restoration efforts and can help guide future improvements with quantitative performance measures in an adaptive management mode.

Research Performance Measure: We attained our primary objective: to develop an hydrological model that can be used as an ecosystem restoration management tool for Faka Union Bay.

Developing Site Fidelity and Essential Habitat Assessment Tools for Juvenile Snappers in Western Sambo Ecological Reserve Florida Keys National Marine Sanctuary

S. Whitcraft (UM/CIMAS); B. Richards and J. Lamkin (NOAA/SEFSC);
N. Davis (NOAA Corps/SEFSC); L. Pytko (New College of Florida)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To understand the life-history habitat-protection requirements for a recreationally and commercially important reef-associated snapper species such as yellowtail snapper (*Ocyurus chrysurus*).
- **Strategy:** To implement a micro-acoustic tagging study using customized acoustic arrays and micro-tagging technology to focus on tracking small juvenile snappers in the Western Sambo Ecological Reserve (WSER) and associated habitat areas in Florida Bay.

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Plan Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

Snapper are one of the most heavily fished species in Florida waters. In order to properly manage this important commercial and recreational fishery, we need to have a better understanding of the movements of juvenile snapper within and between habitat types and with reference to marine protected areas (MPAs). Therefore, the research question we are asking is, what are the juvenile habitat protection requirements for a reef-associated snapper species, such as yellowtail, *Ocyurus chrysurus* and gray snapper, *Lutjanus griseus*.

We are collaborating with the Pacific Northwest National Laboratories (PNNL) to apply their juvenile salmon tagging and micro-acoustic tracking tools to our pilot study objectives (Figure 1). The long-term goal is to further develop and use cutting-edge, customized acoustic arrays and surgically implanted micro-acoustic tags (originally developed to track migration and survival of salmon smolts in the Pacific Northwest) to focus on tracking small, 75 to 125 mm, juvenile snapper movements and home-ranges. Research is centered on habitat areas both in the Western Sambo Ecological Reserve and in habitat areas in Florida Bay. In Western Sambo Ecological Reserve's (WSER) patch reefs and in Florida Bay's seagrass beds, we are training to set-up acoustic arrays in order to track site fidelity and home-ranges of small, young-of-the-year snappers within and between habitats. We are focusing on WSER because it is the only FKNMS ecological reserve that protects three known nursery and juvenile snapper habitats: coral/patch reefs, sea-grass beds/hard-bottom, and mangrove shoreline. This unique configuration allows us to investigate the effectiveness of marine protected areas from a multi-habitat, ecosystem-level perspective. Understanding site fidelity, home-ranges, and habitat use patterns of these juvenile fishes both within and between fully protected areas and in non-protected areas is essential to aid in understanding the dynamics and effectiveness of current and future MPAs in the Florida Keys National Marine Sanctuary.

This is the first year of our pilot micro-acoustic tagging project. We focused on joint training with PNNL staff. Training included micro-tag activation using soldering iron and dissecting microscope and micro-tag surgery techniques (Figure 2). Project personnel were also trained in deploying acoustic arrays in shallow water, range-testing, and data interpretation. Initial capture and care protocols for juvenile snappers are being established and implemented at the State of Florida's Institute of Oceanography – Keys Marine Laboratory, Long Key.

Research Performance Measures: All activities are on schedule in this, the first year of this program



Figure 1. Sample micro-acoustic tag (PNNL Labs) to be used in tracking the movements of juvenile snappers. Photo: T. Carleson, Ph.D.



Figure 2. CIMAS staff training in surgical implementation of micro-acoustic tags. Photo: S. Whitcraft.

Demographic Monitoring of *Acropora palmata* in the Florida Keys

D.E. Williams, and B. Mason (UM/CIMAS); M.W. Miller (NOAA/SEFSC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To determine the relative importance of each 'threat' (disease, predation etc.) among the remaining elkhorn populations in the upper Florida Keys
- **Strategy:** To assess on a quarterly basis the status of individually-tagged colonies of coral at several sites in the upper Florida Keys National Marine Sanctuary (FKNMS)

CIMAS Research Theme:

- **Theme 3:** Regional Coastal Ecosystem Processes

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

Research Summary:

Elkhorn coral (*Acropora palmata*) is one of the dominant framework builders on Caribbean reefs. Because of its structural complexity and very fast growth rates it is ecologically irreplaceable on Caribbean reefs. Elkhorn populations in the Florida Keys and throughout the Caribbean have declined by more than 90% since the 1980s. The remaining population is faced with a variety of natural and anthropogenic pressures that threaten population-level recovery including disease, predation, fragmentation and overgrowth by sponges and algae. Elkhorn coral is currently being proposed for listing as 'threatened' under the Endangered Species Act. If the proposed listing is approved NOAA Fisheries will develop a recovery plan based on the current status and threats to these corals in US waters.

The overall objectives of this project are to document the status and distribution of the remaining elkhorn populations in the upper Florida Keys and to determine the relative importance of the various 'threats' (disease, predation etc) present in those populations. This project consists of a mapping and demographic monitoring components. The monitoring component is conducted at fifteen study plots established at 5 reefs in the upper FKNMS. All elkhorn colonies in the study plot were carefully mapped and approximately 12 colonies within each plot were selected randomly and tagged (n=188). Every three months the tagged colonies are photographed and assessed for the presence of any threats and the entire study plot is searched for new 'recruits' to the population.

To date we have observed that disease has had the most profound impact on the population. While the pathogen remains unidentified, disease manifestations are generally consistent with white pox. Prevalence of this disease varies greatly over space and time, generally increased in the summer months. Predation also varies over space and time and results in tissue loss, but at a much slower rate than disease. In spite of the very active 2004 hurricane season, relatively little physical damage resulted from the hurricanes. However, Hurricane Dennis in July 2005 caused widespread fragmentation and likely exacerbated disease impact on the population (Fig.1). Two thirds of tagged colonies showed active disease signs that coincided precisely with the hurricane. At the last survey approximately 70% of the storm generated fragments were rapidly losing tissue which suggests that asexual recruitment will be minimal.

The mapping component of this project aims to survey shallow reef areas and mark *Acropora* spp. colonies using GPS. These points along with surveyed tracks are entered into a GIS database. The resulting map will provide a valuable tool for monitoring long term changes in the status of this threatened species.

Research Performance Measure: All aspects of this program are successfully on schedule.

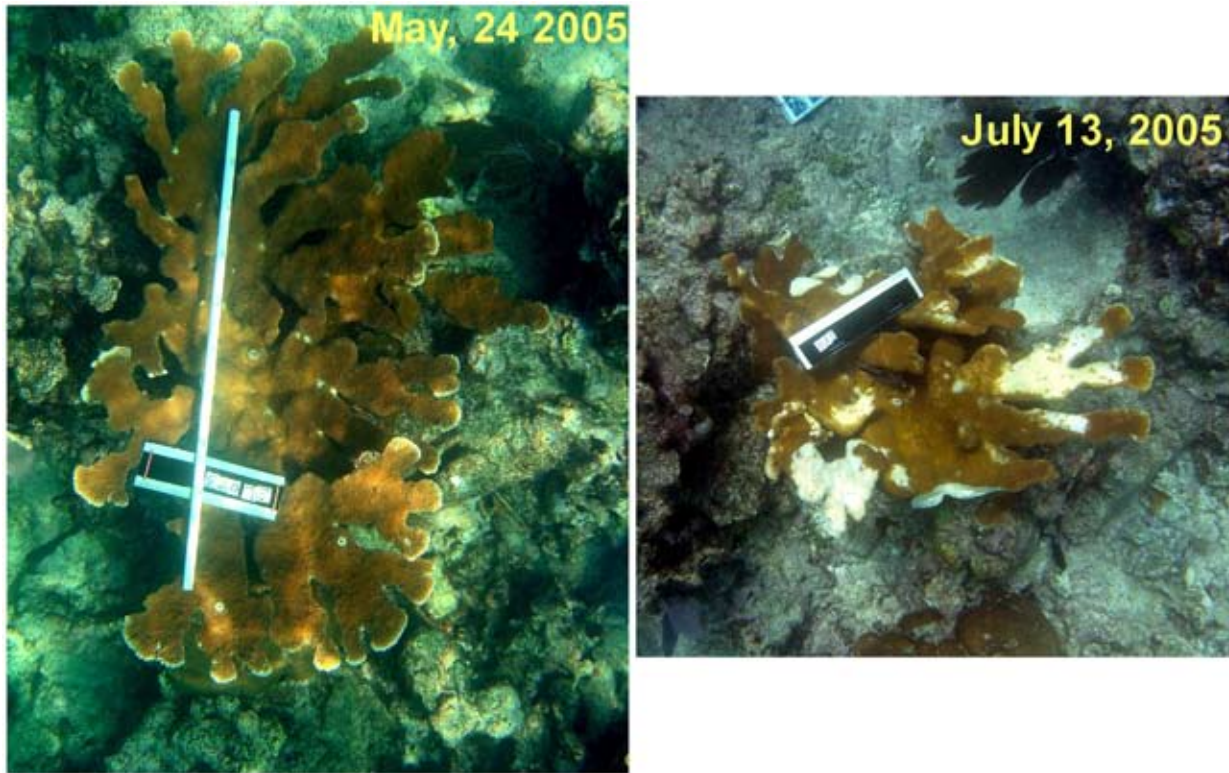


Figure 1. Tagged *Acropora palmata* colony at Elbow Reef in the Florida Keys in May 2005 and the same colony 4 days after Hurricane Dennis passed approximately 400 km to the west. Note the dramatic decrease in size due to fragmentation of the colony and the large bright white areas indicating freshly exposed (within 3 to 4 days) skeleton (rectangular board is 30cm, photos have been scaled to equivalent size for comparison).



Assay and Sensor Development to Identify, Detect, and Quantify Microbial Contaminants

I.B. Baums and C. Garcia, (UM/CIMAS);
J.W. Fell (UM/RSMAS); K. Goodwin (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To increase the social and economic value of marine resources by improving coastal water quality monitoring.
- **Strategy:** To develop a rapid hybridization technique utilizing DNA probes capable of simultaneously detecting several fecal indicators.

CIMAS Research Theme:

- **Theme 4:** Human Interactions with the Environment

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

Microbial contamination impacts coastal water quality. Environmental managers need quick and accurate measures of water quality so that they can restrict human access to contaminated marine waters. However, current monitoring techniques for fecal contamination are too slow and labor intensive, which makes environmental study and management difficult.

We have developed a molecular method to detect and identify fecal contamination in coastal waters based on the Luminex xMAP™ hybridization and detection system. Luminex is well suited to rapidly detect a variety of bacterial species that indicate contaminated water because it provides high throughput, multi-target detection. The Luminex 100 is essentially a flow cytometer equipped with two lasers, one that identifies a color-coded bead (there are 100 available) and the other that registers whether or not the capture probe has captured a target (e.g., DNA, RNA, protein, antigen). This effort will benefit the public and the economy by aiding water

quality managers, policy makers, public health agencies, and the aquaculture industry to make rapid, informed decisions about water quality

We tested this system in both laboratory and field samples. We developed several group-specific primers and species-specific probes to detect a variety of fecal indicating bacteria including total coliform bacteria, the *Bacteroides fragilis* group, *Escherichia coli* and *Shigella* sp., *Enterococcus faecalis*, *Enterococcus hirae*, *Enterococcus flavescens* and *Bacteroides distasonis*. The *Bacteroides* species are promising alternative indicator organisms, and it is thought that they can be used to distinguish human-derived sewage. The primers and probes target the LSU (16S) of bacterial rDNA.

We showed that the Luminex assay was sensitive and specific based on laboratory studies; therefore, we turned our efforts toward environmental samples. We tested river water, beach water, and beach sand. Our river site (Wagner) was substantially more contaminated than the beach site (Hobie), Hence, there was substantially more target available for detection by the Luminex assay in the river site (Fig. 1). Correspondingly, the Luminex response was stronger for the river samples, and it was often below detection for the beach samples (Fig. 2).

An interesting result from the sequencing effort was the large number of undocumented taxa in the samples. The specificity of our probes and primers was tested in silico by searching known bacterial sequences in GenBank for sequence similarity and identity. Given the large number of sequences we found in the environment that were not yet contained in GenBank, we were concerned that our probes may not be specific to the species for which they were designed. However, analysis of the aligned sequences indicated that our probes did not cross-react with any of those sequences, suggesting that they were indeed specific for the target despite the rich (and previously undescribed) genetic diversity present in the samples. This work has paved the way for using Luminex to routinely monitor water quality in the tropical oceans

Research Performance Measure: All objectives are being met on schedule.

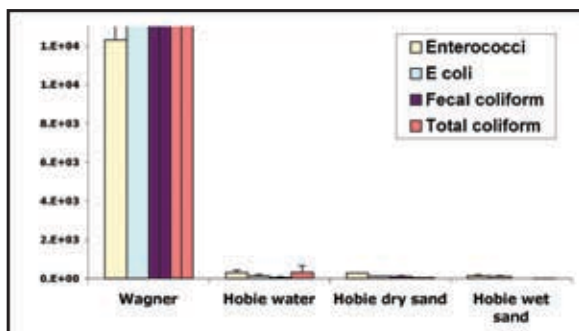


Fig. 1. Average number of cells available for detection by the Luminex assay for Enterococci, *Escherichia coli*, fecal coliform, and total coliform from a river (Wagner) and a beach (Hobie water, dry sand, or wet sand). Error bars represent the standard deviation of the mean for 3-4 collections sampled within 1 year.

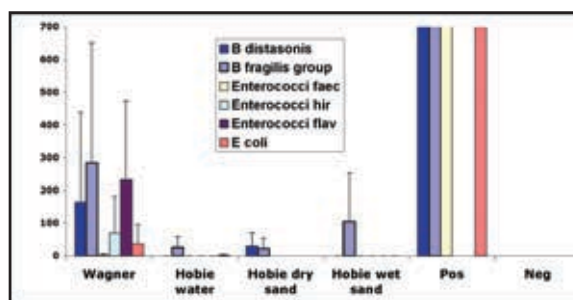


Fig. 2. Luminex detection of fecal indicating bacteria in environmental samples. Environmental samples were PCR-multiplexed and then hybridized to taxa-specific probes. Shown is the mean corrected fluorescence [+ 1 standard deviation] for 3-4 samples per site collected over one year.

Electrochemical Biosensors for Improved Protection of Coastal Resources and Public Health

M.J. LaGier and C. Garcia (UM/CIMAS); J. Fell (UM/RSMAS);
K. Goodwin (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To increase the social and economic value of marine resources by improving the monitoring capabilities for harmful microorganisms in coastal waters.
- **Strategy:** To develop portable and remotely-accessable electrochemical biosensors that can rapidly detect microbial fecal indicators, harmful algae, microbial pathogens and source tracking markers in coastal waters.

CIMAS Research Theme:

- **Theme 4:** Human Interactions with the Environment

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.

Research Summary:

Microbial contamination and toxic algal blooms negatively impact ecosystem and human health and adversely affect coastal economies. As the nation's coastal areas become more urbanized, poor water quality has increasingly negative economic, health, and environmental impacts. Harmful algal blooms (HABs) alone cost the United States 50 million dollars per year, and sewage-polluted waters have deleterious consequences to human and ecosystem health and the economy.

Current monitoring techniques are too slow and labor intensive; making management decisions, ecological study, and assessment of control measures difficult. Rapid water quality data, in conjunction with environmental parameters and information about the sources of impairment, is needed to guide remediation strategies and help water managers formulate policies based on solid science. Biosensors could improve monitoring by rapidly detecting microbial contaminants. A robust sensor design is needed; for example, one that can be adapted to detect not only harmful algae and fecal indicators, but also fecal and non-fecal pathogens and source tracking markers.

Our program uses genetic markers (DNA sequences) to indicate the presence and abundance of microorganisms within a coastal water sample. We are developing marine biosensors to measure genetic markers via cutting-edge electrochemical detection methods. Unlike other molecular detection methods, electrochemistry offers technology that is small, inexpensive, and portable (Figure 1). In addition, electrochemical biosensors have potential to be integrated into existing NOAA marine vehicles, moorings and instrumented platforms; as well as future remote sensing platforms including the Integrated Oceans Observing System (IOOS).

One of the first challenges of our research is the adaptation of electrochemical methods for coastal water analysis. Our preliminary efforts indicate that electrochemical assays are well suited for this purpose. With our industrial partner, we demonstrated the robustness of electrochemical techniques by detecting bacterial contaminants of coastal waters (*Escherichia coli* and *Enterococcus faecalis*), HABs (*Karenia brevis*), and yeasts (*Cryptococcus neoformans*). The detection of genetic markers directly from cell homogenates or membrane filters, without needing nucleic acid isolation steps, was also demonstrated (Figure 2). The impact of this finding is greater simplicity and reduced costs for engineering portable and in situ biosensors. We are currently improving the sensitivity and quantitative character of the electrochemical methods showing the most promise as water quality monitoring tools. In addition, the most promising methods are being adapted for use in testing a prototype, portable biosensing instrument.

Research Performance Measure: All objectives are being attained on schedule.

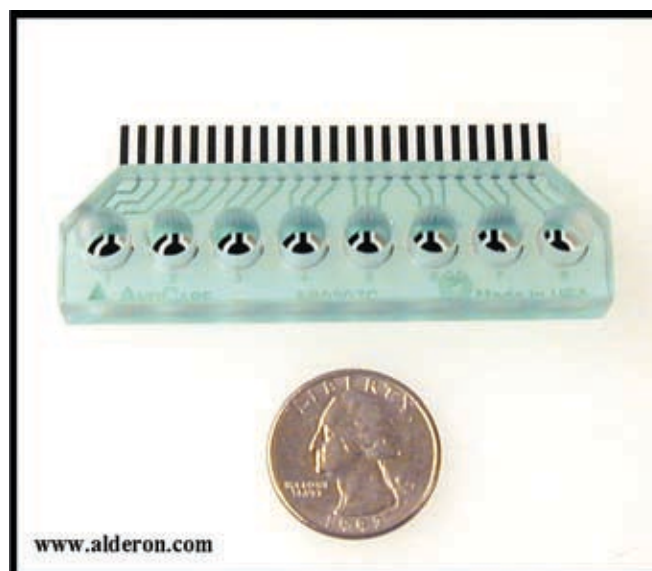


Fig. 1-Electrochemical Biosensors for Improved Protection of Coastal Resources and Public Health.

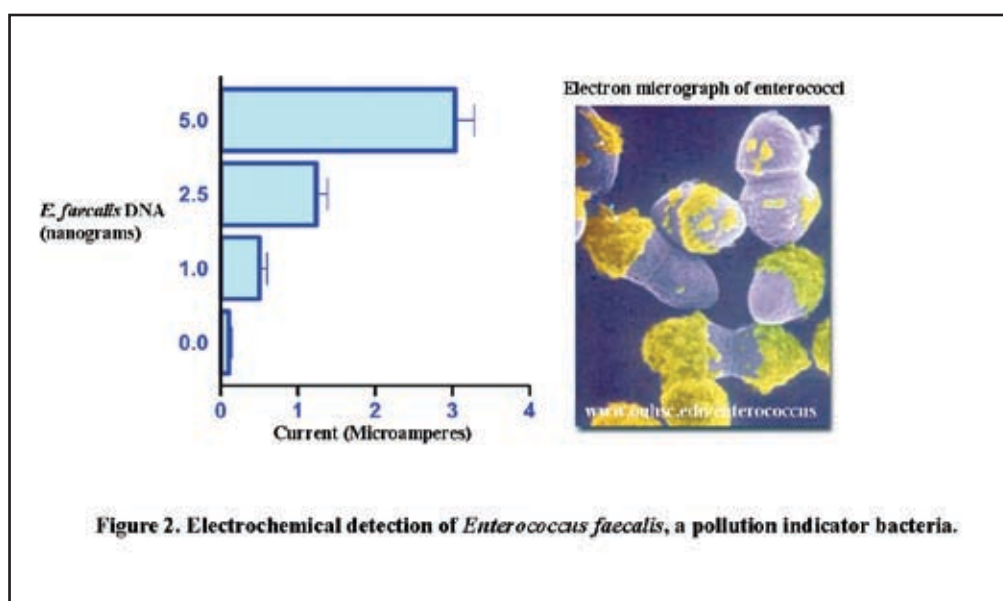


Figure 2. Electrochemical detection of *Enterococcus faecalis*, a pollution indicator bacteria.

Climate Information System for Agriculture and Water Resources Management in the Southeastern USA: The Southeastern Climate Consortium (SECC)

G.P. Podestá, D. Letson and K. Broad (UM/RSMAS);
F. Miralles-Wilhelm, S. Ahmad and R. Garcia (UM/Engineering);
J.W. Jones, C.W. Fraise, S. Jagtap, C. Porter and K.T. Ingram (Univ. of Florida, Agricultural and Biological Engineering); P. Hildebrand (Univ. of Florida, School of Natural Resources and the Environment); J.J. O'Brien and D. Zierden (Florida State University); G. Hoogenboom, D. Stooksbury, C. Roncoli and J. Paz (Univ. of Georgia)

Long Term Research Objectives and Strategy to Achieve Them:

- Objective: To develop a climate information and decision support system for the Southeastern USA that will contribute to an improved quality of life, increased profitability, decreased economic risks, and more ecologically sustainable management of agriculture, forestry, and water resources.
- **Strategy:** To use advances in climate sciences, including improved capabilities to forecast seasonal climate, to provide scientifically sound information and decision support tools for agriculture, forestry, and water resources management in the Southeastern USA.

CIMAS Research Themes:

- **Theme 4:** Human Interactions with the Environment
- **Theme 1:** Climate Variability (secondary)

Link to NOAA Strategic Plan Goals:

- Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.
- Goal 3: Serve Society's Needs for Weather and Water Information. (secondary)

Integrated Research Summary:

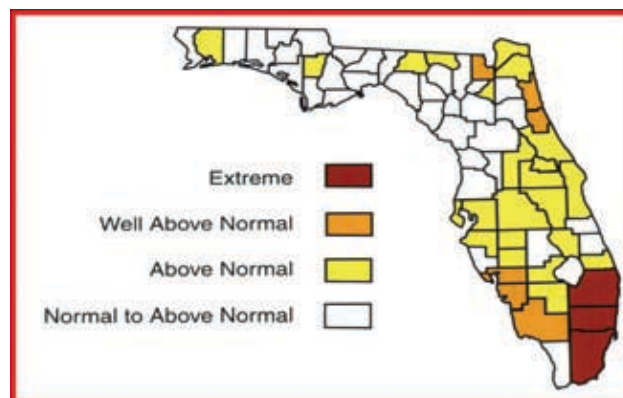
We explore the process of using an ENSO forecast system to provide tailored output for various socioeconomic sectors in small regions, primarily the Southeast United States and Southeast South America. To this end we use nested, coupled, regional climate models to prepare the forecasts. However, these models only have skill in predictions of seasonal climate anomalies; further work is needed to resolve the complete spectrum of anomalous climatic behavior required for agricultural and climate study purposes. In order to obtain useful products, we use various methods of "downscaling" the model results. Additional research at the SECC includes the integration of weather generators with climate models; the assessment of agricultural impact through the analysis of historical crop yields and simulated yield potentials; understanding forestry risk and its minimization; water quality assessment and policy analysis; and the development of crop management optimization toolkits and programs to explore optimal management options under different ENSO conditions and optimization criteria.

Component Programs

The groups at the University of Florida, the Florida State University, and the University of Georgia operate under subcontracts to the University of Miami. In the following sections we present the research summaries of each of the four universities.

University of Miami

We have developed and adopted various methodologies to identify climate variability patterns in temperature and precipitation which we can associate with ENSO events and we relate these patterns to agricultural and water resource impacts. We have implemented a new type of weather generator, a hybrid generator that combines parametric and non-parametric approaches. The parametric component is used for rainfall generation:



a Markov chain of order 1 and three states (dry, low precipitation, high precipitation) is used to adequately replicate the number of rainfall days in a period, and the lengths of wet and dry spells. The non-parametric component is used for generation of daily temperatures and solar radiation, and it involves direct resampling of historical weather data using a conditional bootstrap based on nearest neighbor probability density estimation. Another research line has focused on quantifying the boundaries between terciles of climatological distributions of total precipitation and average temperature for the US southeast. The terciles are used to define “above normal”, “near normal” and “below normal” categories in seasonal climate forecasts.

Additional research includes: the integration of weather generators with climate models; the assessment of agricultural impact through the analysis of historical crop yields and simulated yield potentials; water quality assessment and policy analysis; and the development of crop management optimization toolkits and programs to explore optimal management options under different ENSO conditions and optimization criteria.

University of Florida

The UF program focuses on improving downscaled climate forecasts. Climate forecasts may be downscaled for a region by using nested models within the cells of a global circulation model (GCM). These downscaled results, however, have relatively poor skill at a 20 km _ 20 km grid size. A statistical method based on nearest-neighbor analogue technique was developed to downscale global climate model outputs given by the coupled Atmospheric-Oceanic General Circulation Model developed by FSU/COAPS to local surface temperature, solar radiation, and rainfall in Southeastern US. One objective is to understand how crops respond to climate variability under different phases of the El Niño Southern Oscillation (ENSO) phenomenon. To this end we are using crop simulation models for tomato, peanut, and potato in combination with historic weather data and daily data generated through resampling. We obtain a series of probability distribution functions to show crop response. Simulations were run under a range of crop establishment dates, fertilizer application rates, and irrigation regimes. A Visual Basic program was written that allows extension agents, farmers, and other to explore this database so that they can see how crops are likely to respond under different ENSO conditions, including under current climate forecast conditions. This program allows agricultural extension agents and farmers to incorporate climate information, including climate forecasts, into their decision-making processes. In order to increase access of decision makers to the decision support tools developed by the SECC, UF has led the development of a web site that will eventually be open to the general public. Personnel from UM, FSU and UGA have also made important contributions to this web site. A beta-test version of the web site may be viewed at: <http://www.agclimate.org/>

Florida State University

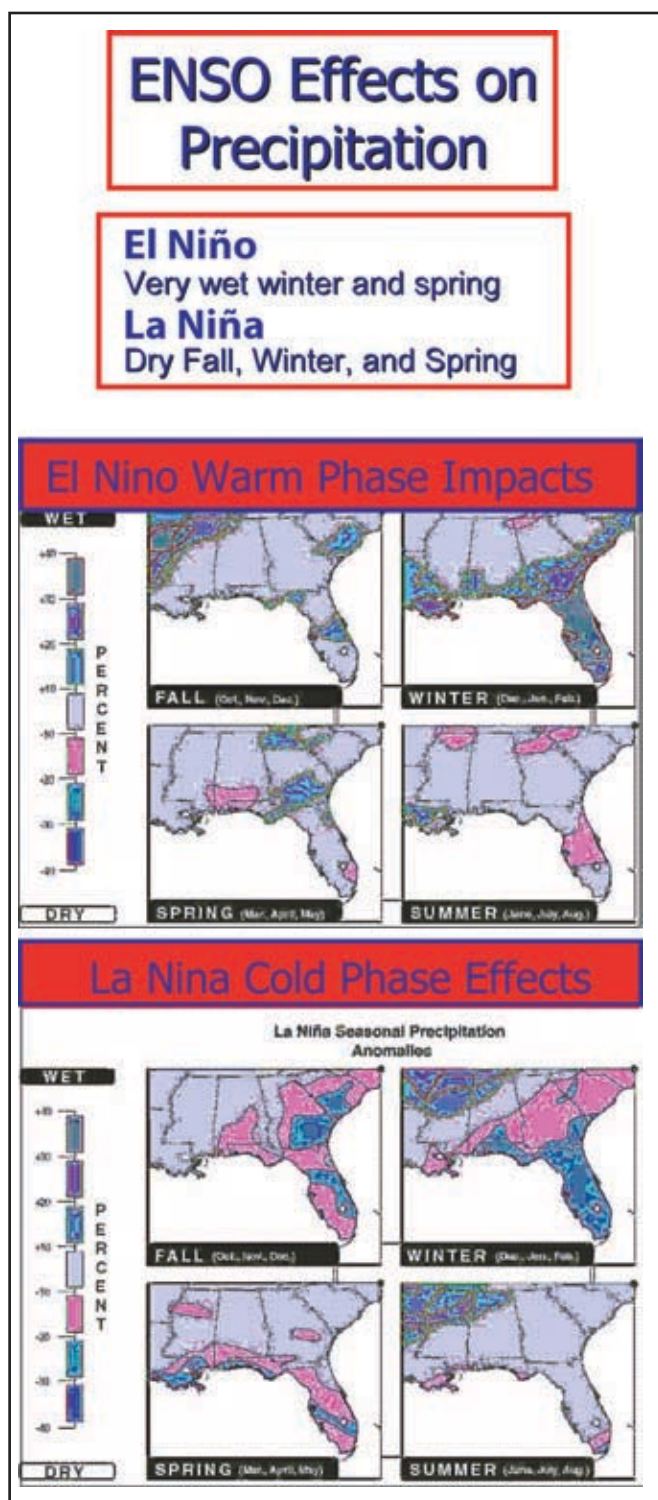
We have shown that different phases of ENSO have unique, quantifiable impacts on the Southeastern US and the rest of the world. We apply this research, using historical climate data, to understand these impacts and identify areas where they can be expected. We are working to improve downscaled climate forecasts by using nested models within the cells of a global circulation model (GCM) using the University of Florida statistical method described above. The downscaling procedure uses the global climate outputs from the FSU/COAPS coupled Atmospheric-Oceanic General Circulation Model to generate local surface temperature, solar radiation, and rainfall in Southeastern US. Downscaled outputs significantly improved the skill of raw GCM forecasts of temperature, radiation, and precipitation. Crop yields forecast using downscaled climate data as inputs to crop simulation models have higher skill (~0.60 or better) than traditional GCM forecast climate data.

University of Georgia

The calibration and evaluation of crop models requires experimental data for crop growth and development, yield and yield components, and management practices. However, the dynamics of the agricultural technology, such as new varieties that are released, is not matched with the frequency by which field experiments can be carried out to obtain the required data set for calibrating crop models. As a result, there is a lack of cultivar coefficients describing new and recently released varieties. Further, crop models should be evaluated with field data for a wide range of environmental conditions and management practices to provide credibility prior to applications for decision making. An accurate simulation of irrigation water use is needed to help improve yield predictions. It will also contribute to the resolution of an ongoing tri-state (Alabama, Florida and Georgia) water dispute.

We used an optimization procedure to estimate the cultivar coefficients for widely-grown peanut varieties in southeastern USA as well as for new and recently released varieties. At the same time, we evaluated the performance of the DSSAT Cropping System Model in simulating irrigation applications and its impact on yield in farmers' fields in southwest Georgia. Crop growth and development variables and farmers' management practices such as irrigation applications were collected during the 2004 and 2005 growing seasons. Long-term daily weather data are required for many applications of decision support systems in agricultural and natural resource management. The availability of daily solar radiation has been limited until recent years, restricting the application of crop and natural resource management models when long-term solar radiation data are required. We used a computer program, WGENR, to generate daily solar radiation data for selected counties in Alabama, Florida and Georgia using locally observed maximum and minimum temperature and precipitation data as input.

Research Performance Measure: The goals in the development of models and forecast-information systems have been met on schedule.



Technology Transfer: Luminex and Microplate Detection of Microbial Contaminants in Coastal Water

J. Fell (UM/RSMAS); K. Goodwin (NOAA/AOML),
M. O'Donovan Dix (RTI - subcontract)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To complete a market analysis for two technologies for analysis of microbial contaminants in coastal waters (microplate assay and LuminexTM); to write and submit a report on the market analysis.
- **Strategy:** To conduct a “SWOT” analysis -- strengths, weakness, opportunities, threats -- on the technologies; to gather background information, preliminary market intelligence, analyze the information, and synthesize the information and recommendations in a report.

CIMAS Research Theme:

- **Theme 4:** Human Interactions with the Environment

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.
- **Goal 3:** Serve Society's Needs for Weather and Water Information. (secondary)

Research Summary:

As a part of another CIMAS-related activity two DNA hybridization technologies were developed in collaboration with NOAA AOML (see: **Theme 4:** Assay and Sensor Development to Identify, Detect, and Quantify Microbial Contaminants). Both assays incorporate molecular biological methods for detection of microbial contaminants in coastal waters. The microplate plate assay is a colorimetric assay developed to detect the presence of harmful algae. The LuminexTM-based assay was developed to detect a variety of fecal indicating bacteria.

RTI was tasked with performing a market analysis for these two technologies. RTI explored a variety of potential coastal environmental markets for the microplate and Luminex-based assays. These markets can be divided into the following broad sectors: Risk management - agencies managing the human health risks associated with using recreational waters and consuming shellfish; Natural resource management - agencies managing fisheries, threatened or endangered species, and exotic species; Aquaculture - industry involved in raising, harvesting, and processing finfish and shellfish; Environmental research.

The market analysis suggested that opportunities exist for both assays across multiple coastal-environmental markets. The Luminex-based approach stands out because of its high throughput and multiplexing capabilities. This assay could be useful in a variety of sectors. The market that seemed best suited for the least amount of developmental effort is to adapt the Luminex assay for microbial source tracking. Market opportunities also exist for the assays in the natural-resource management and aquaculture sectors. In both of these sectors, the assays' current qualitative capabilities are sufficient for meeting end-user needs. Several companies were interviewed during the course of the market analysis with regard to the Luminex-based assay. Luminex Corp., as well as several companies that repackage the Luminex systems for more tailored uses, expressed potential interest in teaming with the UM/AOML assay developers for commercialization efforts in coastal markets

Research Performance Measure: The market analysis and report were completed.



Air-Sea Flux Estimation in High Wind Boundary Layers; Air-Sea Fluxes in High Winds – Analysis of the CBLAST Data

W. Drennan (UM/RSMAS)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To improve forecast accuracy for hurricanes and tropical systems.
- **Strategy:** To provide direct measurements of the air-sea fluxes of momentum, heat and moisture in hurricane conditions as a part of the CBLAST initiative.

CIMAS Research Theme:

- **Theme 5:** Air-Sea Interactions and Exchanges

Link to NOAA Strategic Plan Goals:

- Goal 3: Serve Society's Needs for Weather and Water Information.

Research Summary:

Latent heat fluxes are a critical air-sea interaction parameter, one that is particularly important with respect to the development of tropical storms. Accurate fluxes are needed as input parameters to coupled hurricane forecast models. Hurricane reconnaissance flights routinely monitor latent heat fluxes. It is important to have an instrument that is accurate and has a fast response rate. As a part of this program we developed a fast-response hygrometer. The humidity data along with turbulence and supporting measurements enables the calculation of latent heat fluxes with increased accuracy and precision and lead to improved hurricane forecasts.

We carried out turbulence and supporting measurements from P3 aircraft during hurricanes Fabian and Isabel. A typical flight track is shown in Figure 1. A new fast response hygrometer system developed by the PI for the project worked well. We have now calculated the air-sea fluxes of humidity and momentum, along with their bulk transfer coefficients. The bulk humidity transfer coefficient or Dalton number, C_{E10} is shown in Figure 2. These are the first data for winds speeds above 20m/s. The CBLAST data are seen to be consistent with the earlier HEXOS data, with no wind speed dependence for winds up to 30m/s. This implies that the effects of sea spray on the humidity flux, if any, is limited to higher wind speeds.

Research Performance Measure: Data analysis is in progress, and on schedule.

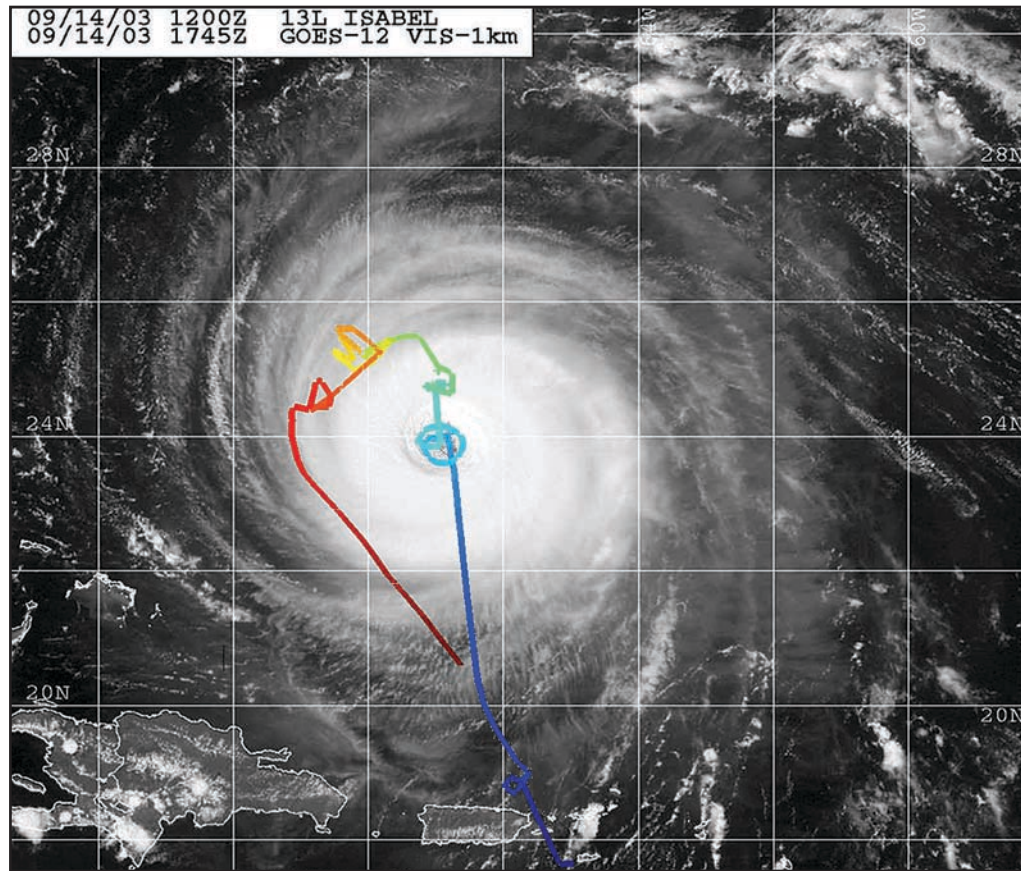


Figure 1: CBLAST Flight track of N43 into Hurricane Isabel, 14 September 2003. The flight track is superimposed on a NOAA GOES-12 satellite visible image from 1745 UTC, when the aircraft was in the eye.

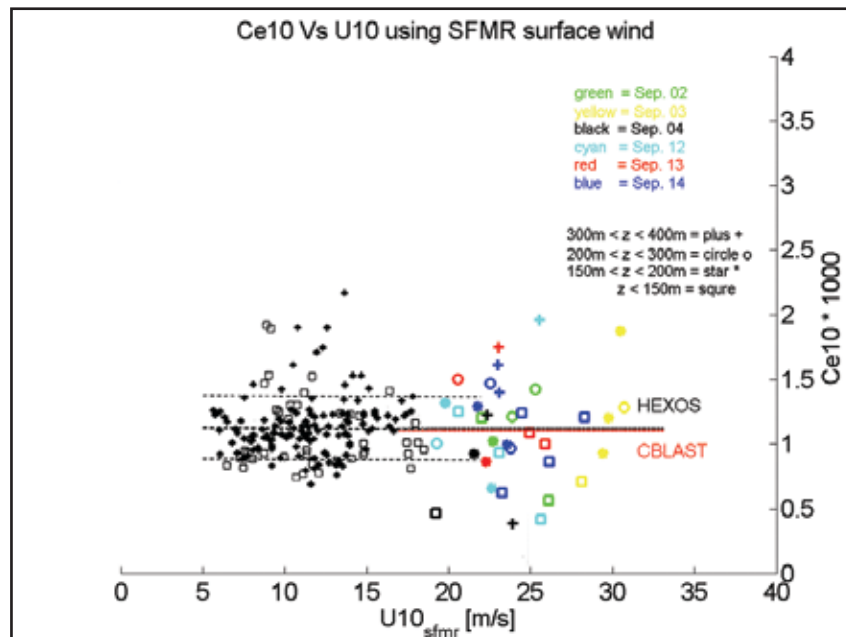


Figure 2: Dimensionless bulk humidity coefficient or Dalton number versus wind speed. The plot shows the new CBLAST data along with the earlier HEXOS data from DeCosmo et al 1996.

Initial Steps Towards a Global Surface Water pCO₂ Observing System

F.J. Millero (UM/RSMAS); R. Wanninkhof and S. Cook (NOAA/AOML);

R. Feely (NOAA/ PMEL); Nick Bates (BBSR, Bermuda);

T. Takahashi (LDEO/Columbia Univ.)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** Determine the changes in the pCO₂ in the Atlantic and Pacific Ocean waters in order to examine the uptake of fossil fuel CO₂ by the oceans over time.
- **Strategy:** This is being done by using volunteer observing ships (VOS) in the Atlantic and Pacific oceans.

CIMAS Research Theme:

- **Theme 5:** Air-Sea Interactions and Exchanges

Link to NOAA Strategic Goals:

- Goal 2: Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.
- Goal 3: Serve Society's Needs for Weather and Water Information. (secondary)

Research Summary:

Understanding the global carbon cycle and the determination of the regional sources and sinks of carbon are of critical importance to international policy decision making, as well as for forecasting long term climate trends. Projections of long-term global climate change are closely linked to assumptions about feedback effects between the atmosphere, the land, and the ocean. To understand how carbon is cycled through the global climate system, ocean measurements are of utmost importance. In this effort NOAA is outfitting research and commercial vessels with automated carbon dioxide sampling equipment to analyze the seasonal variability in carbon exchange between the ocean and atmosphere. This task is coordinated at national level with the U.S. Global Carbon Cycle Science program and its subcommittee on Ocean Carbon and Climate change (OCCC). To date it has benefited from the International Ocean Carbon Coordination Project (IOCCP) for international coordination exercises. The IOCCP is a joint endeavor of the SCOR/IOC CO₂ panel and the IGBP-IHDP-WCRP Global Carbon Project. Formal ocean basin ties are now being formed in the Atlantic through a Memorandum of Understanding with the European Union project Carbo-Oceans. Pacific collaboration is established through the PICES working group 13.

Documenting carbon sources and sinks relies critically on other efforts undertaken by the Climate Observations and Services Program, COSP including implementation of the ship lines, and moored and drifting arrays. The surface water pCO₂ programs support climate services by providing knowledge and quantification of climate forcing of the radiatively important gas, carbon dioxide. The near-term focus is on completion of the Northern Hemisphere ocean carbon observing system to assist in determining carbon dioxide sources and sinks over the coterminous United States in partnership with the atmospheric CO₂ observing system.

Two separate proposals have been joined into the underway pCO₂ observing program on volunteer observing ships (VOS) and research ships. It is a partnership of AOML, AOML/GOOS, PMEL, LDEO of Columbia University, RSMAS of the University of Miami, and the Bermuda Biological Station for Research (BBSR). Data from the project is being served from three websites that are linked and accessible from each.

1. <http://www.aoml.noaa.gov/ocd/gcc>
2. <http://www.pmel.noaa.gov/co2/uwpco2/>
3. <http://www.ldeo.columbia.edu/res/pi/CO2/>

All work follows established principles of monitoring climate forcing gases and biogeochemical cycles.

A major component of the VOS pCO₂ work revolved around designing, building and testing the second generation of underway pCO₂ systems for ships of opportunity. A contractor at the University of Bergen built twelve systems with extensive input from the NOAA/COSP sponsored partners. Four of the systems are being purchased by the participants of this project. The others are going to groups throughout the world. The systems were intercompared against each other in Bergen in September 2004 with agreement between systems

being better than 0.5 ppm; well within our performance standard of 1 ppm. Through close interaction of VOS group members with the builder, Craig Neill, we greatly facilitated the production and improvement of these systems. System parts were purchased by the VOS group members and credited towards instrument costs. The first generation systems that we currently have installed on VOS will be retrofitted to be fully compatible with the new systems.

Research Performance Measure: All aspects of the program are on schedule.

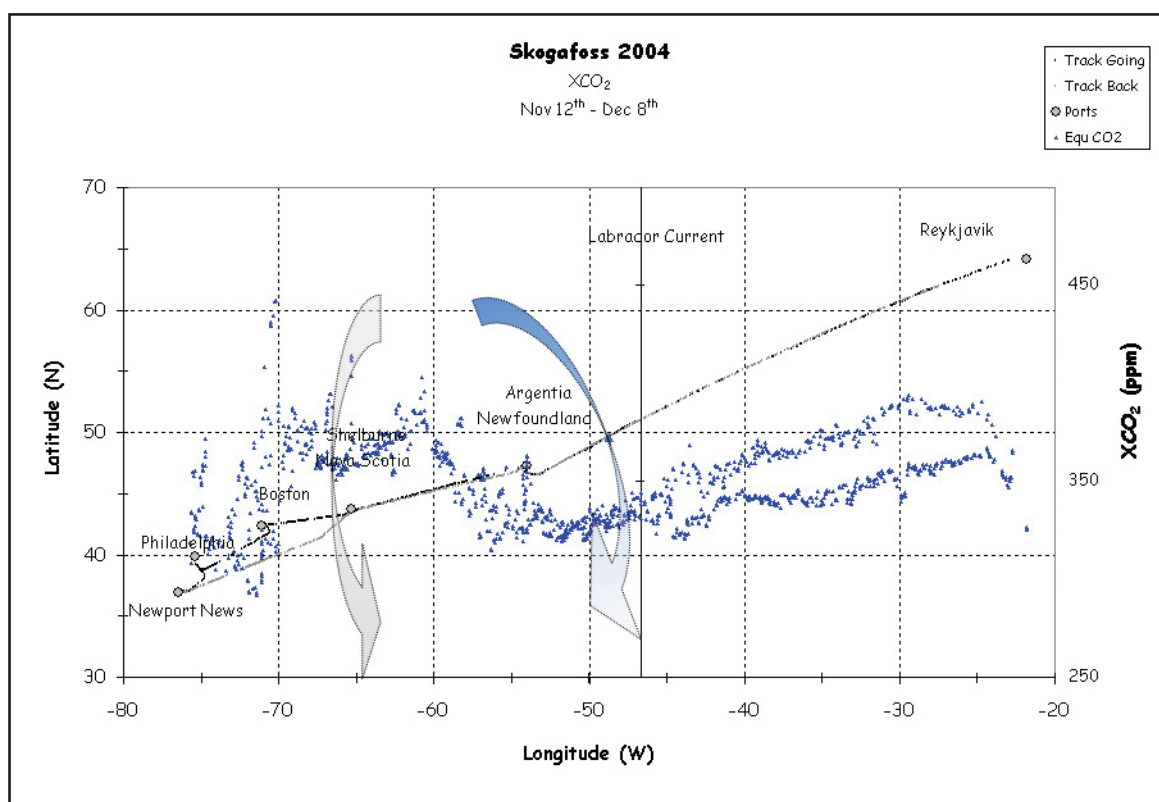


Figure 1. Data collected from November 12 to December 8, 2004 by our pCO₂ system installed on the freight cargo ship Skogafoss.

Targeting Strategies to Improve Hurricane Track Forecasts

S.J. Understanding and Improving the Ensemble Transform Kalman Filter Targeting Strategy

S.J. Majumdar (UM/RSMAS); S.D. Aberson (NOAA/AOML);
C.H. Bishop (NRL/Monterey)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To assess whether upstream observations are useful for 3-7 day forecasts and whether their effects can be predicted in advance on a daily basis.
- **Strategy:** In various flow regimes, test whether the Ensemble Transform Kalman Filter (ETKF) can predict the reduction in forecast error variance due to upstream observations.

CIMAS Research Theme:

- **Theme 5:** Climate Variability

Link to NOAA Strategic Goals:

- Goal 3: Serve Society's Needs for Weather and Water Information.

Research Summary:

A core NOAA objective is to improve 3-7 day forecasts of precipitation over North America. One method of making such improvements is by augmenting the present routine observational network with extra upstream observations. The primary goal of this NOAA/ CIMAS/THORPEX research is to evaluate and further develop the Ensemble Transform Kalman Filter (ETKF) adaptive observing strategy, which is presently used in operational NWS Winter Storm Reconnaissance (WSR) to improve 1-3 day forecasts.

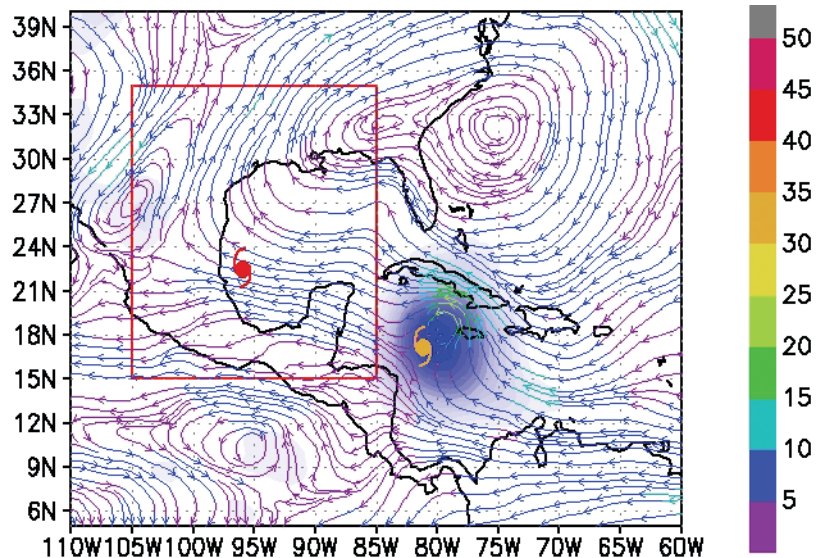


FIGURE 1. Blue shading: ETKF guidance aimed at improving a 3-day forecast of Hurricane Emily's landfall, on 20 July 2005. Contours: 850-200hPa deep layer mean wind at the targeted observing time. Orange and red hurricane symbols represent the ensemble mean track forecast, valid at the targeted observing (17 July) and verification times (20 July) respectively.

In order to assess the performance of the ETKF, the actual influence of observations on numerical forecasts first needs to be analyzed via data denial experiments - that is, experiments in which observational data are selectively withheld from the data assimilation to ascertain what impact they had had on the analysis. Much of the first year has been spent learning to run the "Global Parallel" software at NCEP EMC, using the T126 L28 GFS model with denial of rawinsonde or dropwindsonde data from either (i) east Asia, or (ii) north America, or (iii) WSR flights. Some significant bugs in the software have recently been corrected by EMC personnel. The software is being re-run for a 3-month period during winter 2004/5, to compute "signals" produced by the different observation sets (i.e. differences between operational and data denial runs). The quantitative improvement of these observations on 3-7 day forecasts will then be evaluated.

After the NCEP parallel runs have been re-computed, the ability of the ETKF to predict signal variance of 3-7 day forecasts will be evaluated. Early results (e.g. Fig. 1) indicate that the ETKF shows promise in predicting signal variance provided that observations are selected in locations of high ensemble variance. In locations of low ensemble variance, the ETKF often produces spurious initial long-distance correlations between errors in the observation area and errors in regions of high variance downstream. Results will be updated on the following website throughout the project: <http://orca.rsmas.miami.edu/~majumdar/thorpex/>

In a parallel activity we are collaborating with Dr Daniel Hodyss (Rosenstiel Postdoc) in an attempt to understand the fundamentals of signal growth and propagation. Hövmöller diagrams (Fig. 2) and vertical cross-sections of signals are being analyzed to assess the structure and evolution of data "signals" and forecast improvement. Preliminary results from a small sample indicate that

- (i) Signals produced by dropwindsondes deployed over the NE Pacific reach eastern North America in roughly 3 days, and northern Europe in 6-7 days.
- (ii) Signals in mid-latitudes are affected considerably by propagation of tropical signals caused by tiny initial perturbations.
- (iii) The evolution of signals from targeted data (e.g. WSR dropwindsondes) is generally more coherent than signals from non-targeted data (routine rawinsondes).
- (iv) Downstream effects are important, although it is unclear whether the rapid amplification of a signal downstream is associated with downstream baroclinic development or rapid local growth of a small perturbation (e.g. due to convection).
- (v)

Research Performance Measure: The work in Year 1 has largely gone according to plan, although computational issues and bugs in the operational code at EMC have restricted progress.

Understanding and Improving the Ensemble Transform Kalman Filter Targeting Strategy

S.J. Majumdar (UM/RSMAS); S.D. Aberson (NOAA/AOML);
C.H. Bishop (NRL/Monterey)

Long Term Research Objectives and Strategy to Achieve Them:

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CIMAS Research Theme:

- **Theme 5:** Climate Variability

Link to NOAA Strategic Goals:

- Goal 3: Serve Society's Needs for Weather and Water Information.

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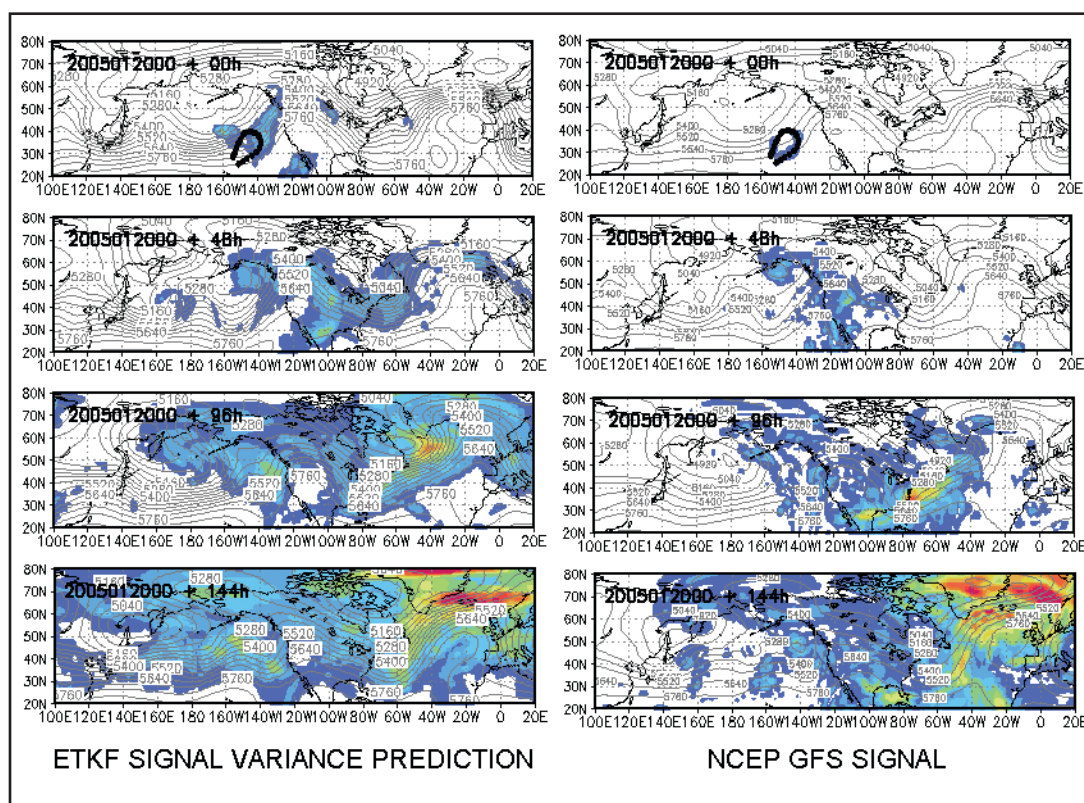


FIGURE 1. (LEFT) Predicted 0-144h ETKF evolution of (u,v,T) signal variance due to east Pacific dropwindsondes released at 00 UTC, 20 January 2005. (RIGHT) Corresponding evolution of actual NCEP signal produced by the dropwindsondes.

In order to assess the performance of the ETKF, the actual influence of observations on numerical forecasts first needs to be analyzed via data denial experiments - that is, experiments in which observational data are selectively withheld from the data assimilation to ascertain what impact they had had on the analysis. Much of the first year has been spent learning to run the "Global Parallel" software at NCEP EMC, using the T126 L28 GFS model with denial of rawinsonde or dropwindsonde data from either (i) east Asia, or (ii) north America, or (iii) WSR flights. Some significant bugs in the software have recently been corrected by EMC personnel. The software is being re-run for a 3-month period during winter 2004/5, to compute "signals" produced by the different observation sets (i.e. differences between operational and data denial runs). The quantitative improvement of these observations on 3-7 day forecasts will then be evaluated.

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- (i) Signals produced by dropwindsondes deployed over the NE Pacific reach eastern North America in roughly 3 days, and northern Europe in 6-7 days.
- (ii) Signals in mid-latitudes are affected considerably by propagation of tropical signals caused by tiny initial perturbations.
- (iii) The evolution of signals from targeted data (e.g. WSR dropwindsondes) is generally more coherent than signals from non-targeted data (routine rawinsondes).
- (iv) Downstream effects are important, although it is unclear whether the rapid amplification of a signal downstream is associated with downstream baroclinic development or rapid local growth of a small perturbation (e.g. due to convection).
- (v) Tracking 'forecast improvement' may be much clearer than tracking signals.

Research Performance Measure: The work in Year 1 has largely gone according to plan, although computational issues and bugs in the operational code at EMC have restricted progress.

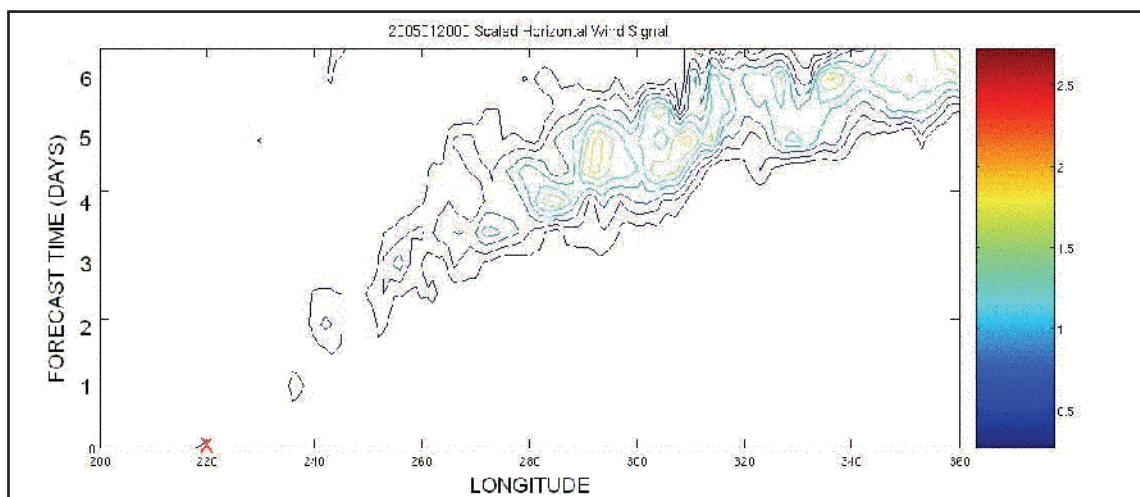


FIGURE 2. Hövmöller diagram showing the 6-day longitudinal evolution of the 100-1000 hPa scaled vertically averaged horizontal wind signal produced by the same dropwindsonde observations of Fig. 1 at 220E. Latitudinal average is between 20-80N.

Development of the WRF Model for Tropical Cyclone Research and Forecasting

D.S. Nolan (UM/RSMAS); M. Bender (NOAA/GFDL);
T. Marchok (NOAA/GFDL); R. Tuleya (NOAA/NCEP)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To continue the development and testing of the Weather Research and Forecast Model (WRF) for future use in tropical cyclone forecasting and research.
- **Strategy:** To perform studies of real-data and idealized data simulations, with close comparison to identical simulations with the GFDL hurricane model, for the purposes of identifying the strengths and weaknesses of the WRF model in regards to hurricane modeling. To develop tools to run the WRF model from various data sets, such as GFDL hurricane model output, and for the analysis and comparison of WRF output with the GFDL model.

CIMAS Research Theme:

- **Theme 5:** Air-Sea Interactions and Exchanges
- **Theme 1:** Climate Variability (secondary)

Link to NOAA Strategic Goals:

- Goal 3: Serve Society's Needs for Weather and Water Information
- Goal 4: Support the Nation's Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation (secondary)

Research Summary:

Our primary goal in Year Two of this project was to look more closely at the structure of the hurricanes as simulated in the WRF and GFDL models. Much of the first half of the year was spent installing and evaluating the most recent version of the WRF model (version 2.0). The new version of WRF has substantial changes in the way it processes both real and idealized data for initial conditions. Furthermore, this version uses a different vertical coordinate system, it took some time and effort to re-design and re-develop the analysis tools (mostly scripts in Matlab) that had been developed to look at model output.

By fortunate circumstance, several high quality and high resolution observational datasets obtained by NOAA researchers have recently become available for storms such as Hurricane Isabel (2003) and Hurricane Ivan (2004). We have decided to focus on the periods of these two storms during which this data was obtained, particularly the dual-Doppler wind analyses observed by the NOAA P-3 aircraft. We are in the process of comparing the observed wind and reflectivity fields with those predicted by the 2005 Operational GFDL Model and WRF 2.0. As shown in the attached figures, the inner-core wind field of Hurricane Ivan, as produced by the model, is much broader and deeper than that observed in the storm. We believe that this large discrepancy is not due to resolution alone, and that it is in part due to the initialization process and model physics. Our analysis of these fields and the preparation of a publication is ongoing.

We have also used WRF model simulations on the NOAA/GFDL computers to study some of the fundamental inner-core processes in tropical cyclones. Previously, we used the model to study inner-core instabilities and the processes by which the vortex adjusts to convection and latent heat release. In recent months, we have used similar idealized simulations to study a new kind of instability which involves a

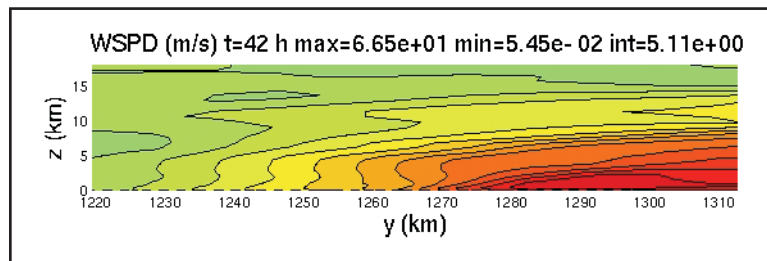


Figure 1: Wind speed in the inner-core of Hurricane Ivan (2004) as produced by the WRF model; the left side of the plot is at the vortex center.

coupling between vortex-Rossby waves in the core and gravity waves in the surrounding flow. This instability may explain why spiral bands are so ubiquitous in tropical cyclones. Other idealized simulations, with moist convection, have shown that the transition from a weak, cold-core cyclone to a strong, warm-core cyclone can be very rapid, and seems to occur when the mid-level humidity reaches a critical value. Further investigation of this process remains for future work.

Research Performance Measure: We have most of the goals for Year Two, such as evaluation of the nested grid capabilities of the WRF model, and evaluation of the various new physics parameterizations. However, our analysis of the structures of the storms in the GFDL and WRF models is not yet complete. This is due in part to the challenge of comparing fields from different models with entirely different data formats; we are close to having a single tool which we can use for both models.

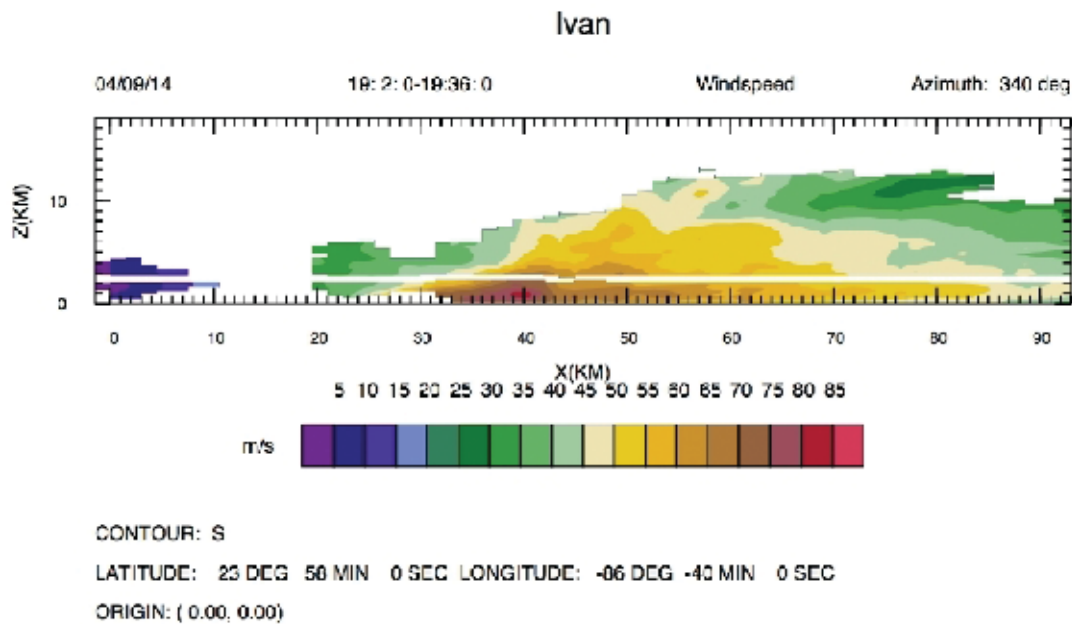


Figure 2: Wind speeds in the inner-core of Hurricane Ivan (2004) as obtained from dual- Doppler analysis of radar data from two NOAA P-3 aircraft. Axes and aspect ratio are the same as in Figure 1

Real-Time Hurricane Wind Analysis

N. Carrasco, N. Morisseau-Leroy, S. Otero and
R. St. Fleur (UM/CIMAS); M. Powell (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To improve our understanding of the wind systems in tropical cyclones.
- **Strategy:** To apply advanced computing methodologies to integrate cyclone data and to make the data more readily available to scientists in real-time.

CIMAS Research Theme:

- **Theme 5:** Air-Sea Interactions and Exchanges

Link to NOAA Strategic Goals:

- Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:

The HRD Real-time Hurricane Wind Analysis System (H*Wind) is a distributed system that ingests real-time global tropical cyclone observations measured by land-, sea-, space-, and air-borne platforms adjusting them to a common framework, 10m marine exposure. These observations are stored in an object-relational database, and then graphically displayed via an interactive Java application where scientists can quality control, objectively analyze, and visualize the information. The H*Wind system consists of five sub-components: data collection, the database, the quality control interface, the analysis package, and the product generation package.

Data collection is accomplished through a suite of Unix scripts and C programs. The current platforms being ingested include Air Force and NOAA reconnaissance, Dropwindsondes, GOES, SSM/I, TM/I and QSCAT satellites, METAR, C_MAN, Buoys, Ships, mobile Towers, MESONET data from FSL MADIS Group. All observations are stored in an object-relational database system consisting of several database schemas and a series

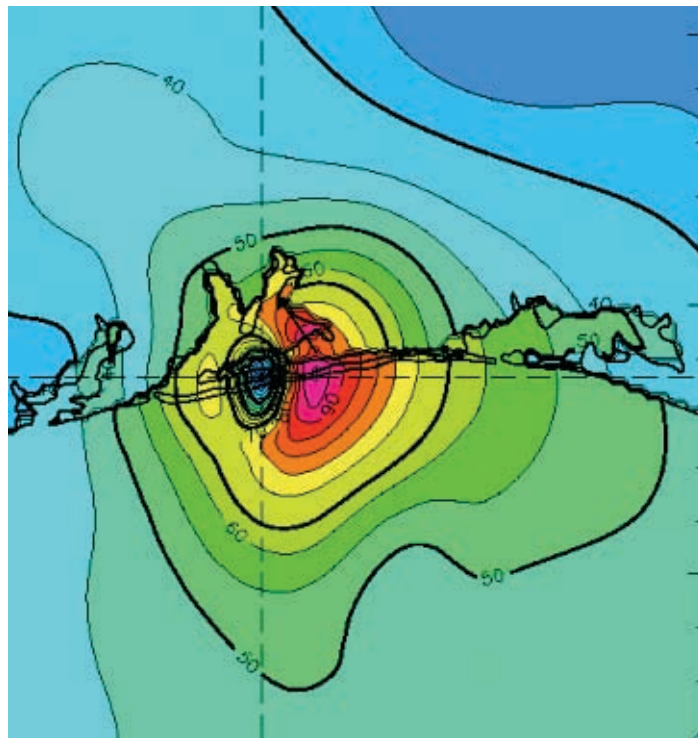


Figure 1. Hurricane Dennis on July 10 showing fields of wind, pressure, temperature and relative humidity.

of PL/SQL and SQLJ components.

The H*Wind Quality Control (QC) Client is the focal point of the H*Wind system. The QC Client allows scientist to interact with the data stored in the database. QC graphically displays the data and allows close inspection, editing or removal of data from the analysis, and customization of analysis parameters.

The analysis algorithm consists of a process of estimating the continuous spatial field of a physical variable from a set of discrete observational data. For our purposes, the physical variables of concern are wind, pressure, temperature and relative humidity. The product of this analysis is a colored and annotated wind contour plot, as seen in Figure 1.

During the past year we developed of a quality control client following the J2EE (Java 2 Enterprise Edition) architecture. This improves timeliness on data retrieval and effectively expands the potential reach to external users beyond the intranet, by conforming to firewall traffic rules. We also converted the gridded output of H*Wind's surface analysis to the industry standard GIS shapefile format for use with FEMA HAZUS model, and to meteorological standard NetCDF. Finally we made improvements in the new database schema to accommodate extensive new user requirements. This included the development of new Oracle PL/SQL procedures, functions, and packages and SQLJ components to improve data ingestion and retrieval.

Research Performance Measure: All objectives are being met on schedule.

Drag Coefficient Distribution and Wind Speed Dependence in Tropical Cyclones

N. Morisseau-Leroy and R. St. Fleur (UM/CIMAS); M. Powell (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To improve the understanding of tropical cyclones through advances in computing technology.
- **Strategy:** To used advanced computing techniques to integrate tropical storm data in near real-time and to make the data available in a flexible format.

CIMAS Research Theme:

- **Theme 5:** Air-Sea Interactions and Exchanges

Link to NOAA Strategic Plan Goals:

- Goal 3: Serve Society's Needs for Weather and Water Information.

Research Summary:

The HRD GPS Dropwindsonde Management Tool (GDDMT) is a robust software tool that allows scientists to manage GPS sonde profiles collected in hurricanes from 1997-2004. These GPS profiles are processed, quality controlled, and organized by mean boundary layer wind speed, storm relative location, and water depth and, then, stored in a modern object-relational database. GDDMT will allow the scientists to ingest GPS profiles into a database, quality control, analyze, update, and query the GPS dropwindsonde data. The tool consists of three sub-components: data collection, the database, and the client interface. Data ingestion and queries are done via Oracle PL/SQL packages that reside in the database and SQLJ components that reside in the application server.

Research Performance Measure: Development of user and programmer use cases, Oracle PL/SQL packages, SQLJ components, decoders and parsers in order to ingest GPS profiles in the database, and a data management tool (see Figures 1 and 2), the GPS Dropwindsonde Management Tool (GDDMT), for viewing and interacting with raw and processed GPS DropWindSonde data are in progress, and on schedule.

Evaluation of a New Operational Stepped Frequency Microwave Radiometer (SFMR)

E.W. Uhlhorn (UM/CIMAS); P.G. Black (NOAA/AOML);
A.S. Goldstein (NOAA/MAO/Aircraft Operations Center)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To evaluate the performance of the NOAA Stepped Frequency Microwave Radiometer and its ability to accurately estimate surface wind speeds in hurricanes in preparation for transition to operations.
- **Strategy:** To finalize instrument calibration procedures; to test surface wind retrievals against in situ measurements under a broad range of wind speeds in the hurricane environment.

CIMAS Research Theme:

- **Theme 5:** Air-Sea Interactions and Exchanges

Link to NOAA Strategic Goals:

- Goal 3: Serve Society's Needs for Weather and Water Information

Research Summary:

The measurement of the hurricane surface wind field, and in particular the estimation of wind maxima, has long been a requirement of the Tropical Prediction Center/National Hurricane Center (TPC/NHC). The NOAA/Hurricane Research Division's (HRD) Stepped-Frequency Microwave Radiometer (SFMR), built by ProSensing Inc., is the prototype for a new generation of airborne remote sensing instruments designed for operational surface wind estimation in hurricanes. The first experimental SFMR surface wind measurements were made in Hurricane Allen in 1980, the first real-time retrieval of winds on board the aircraft was in Hurricane Earl in

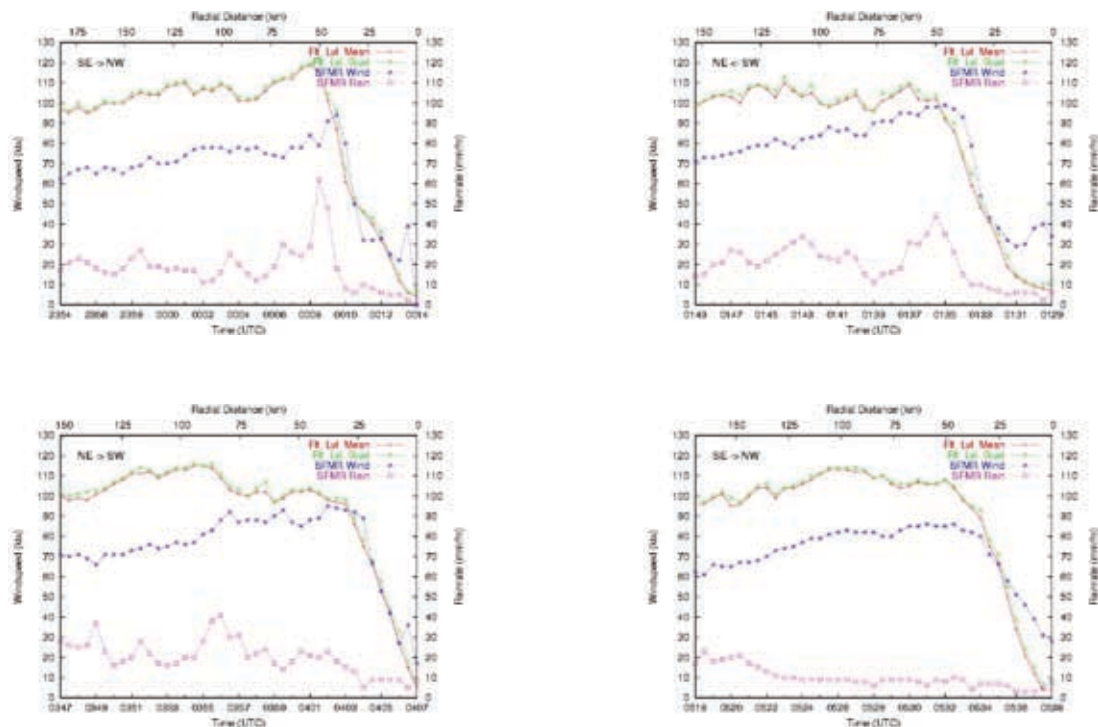


Fig. 1: SFMR-derived surface winds (blue) in m/s along four flight tracks through the center of landfalling Hurricane Ivan on 15 Sept. 2004. Also plotted are the flight-level (3 km) wind speed and rain rate in mm/hr (magenta) as measured by the SFMR.

1985, and the first operational transmission of winds to TPC/NHC was made in Hurricane Dennis in 1999.

Since hurricane reconnaissance began in 1947, numerous methods have been employed to estimate the distribution of surface winds in hurricanes. Sea-state catalogs have provided a subjective guide for the determination of the wind speed. For many years surface winds have been estimated by flight-level measurements using various extrapolation algorithms. Maximum sustained winds have also been estimated using pressure-wind relationships. Studies prior to 1980 have shown that passive microwave emissions from the sea surface are also strongly correlated with wind speed.

The SFMR retrievals of wind speed are based on the observed correlation between wind speed and the increased sea surface microwave brightness temperature due to the presence of wind-generated foam on the sea. Figure 1 shows a time series of SFMR-derived surface winds along the NOAA aircraft flight track in Hurricane Ivan (2004) along with flight-level wind speeds. Our research involves testing the operational SFMR's performance in measuring the critically important surface wind field. We measure performance based on inter-comparisons of SFMR surface wind retrievals with the GPS dropwindsonde measurements which provide the best source of data for this purpose. Details on the SFMR evaluation and the transition to operations can be found at: <http://www.aoml.noaa.gov/hrd/project2005/sfmr.html>

Research Performance Measure: All aspects of the program are progressing satisfactorily.

Evaluation of Upper Ocean Mixing Parameterizations

E.W Uhlhorn (UM/CIMAS); L.K. Shay, and G.R. Halliwell (UM/RSMAS);

S.D. Jacob (Univ. Maryland, Baltimore County)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To improve hurricane intensity forecasting in coupled ocean-atmosphere models currently under development at NOAA's National Center Environmental Prediction (NCEP).
- **Strategy:** To improve model representation of oceanic mixed layers and vertical mixing processes to further our understanding of these processes and their relationship to surface fluxes and the coupled ocean-atmosphere boundary layer.

CIMAS Research Theme:

- **Theme 5:** Air-Sea Interactions and Exchanges.

Link to NOAA Strategic Plan Goals:

- Goal 3: Serve Society's Needs for Weather and Water Information.

Research Summary:

The program seeks to improve model representation of oceanic mixed layers and vertical mixing processes to further our understanding of their relationship to surface and coupled boundary layers. We use the Hybrid Coordinate Ocean Model (HYCOM) with several vertical mixing parameterization schemes to simulate the response to hurricanes Gilbert, Isidore and Lili with realistic forcing. We then compare these simulations to observed current, temperature and salinity profiles obtained with airborne expendable bathythermographs (AXBTs), conductivity, temperature and depths probes (AXCTDs) and current profilers (AXCPs) deployed from NOAA research aircraft.

Studies have substantiated the fact that hurricane intensity is sensitive to upper ocean heat content relative to the 26°C isotherm in the directly forced region of the storm (including recent hurricanes Katrina and Rita). Investigations of ocean response during hurricane Gilbert in the western Gulf of Mexico indicate that the upper oceanic heat and mass budgets strongly depend on the entrainment mixing scheme and the background initial conditions. One of the major uncertainties in a coupled hurricane-ocean forecasting model is the optimal choice of mixing scheme as mixed layer cooling and deepening during storm passage is usually dominated by entrainment mixing away from frontal boundaries and eddies. Using HYCOM configured with different entrainment mixing schemes, we evaluated the simulated and observed fields to assess the appropriate vertical mixing schemes that must be used in coupled models since current (and vertical current shear) is important to mixing and cooling under strong wind forcing.

As the focus is to evaluate the upper ocean heat content and surface fluxes, we simulated the oceanic response with each of five mixing schemes for the Gilbert case. Snapshots of mixed layer temperature response are shown in Fig. 1. All the simulations used the same initial conditions yet there are substantial differences in the magnitude of the cooling in the right-rear quadrant and the spatial pattern. These differences have implications for the oceanic heat content variations and intensity change.

In the case of Hurricane Isidore, initial pre-storm fields are derived from the standard Atlantic HYCOM simulations performed by the Naval Research Laboratory HYCOM group. Satellite altimetric sea surface height anomalies (SHA) from the Modular Ocean Data Assimilation System (MODAS) operational implementation at the Naval Oceanographic Office have been assimilated using a vertical projection technique. Ocean eddy and boundary current positions are reproduced accurately by this technique, but thermal structure profiler data indicates that the model fields underestimate isotherm depths and upper ocean heat content (Fig. 2a). *MODAS, SHA-derived and observed oceanic heat content and 26°C isotherm depths estimates were consistent in the NW Caribbean Sea in contrast to the HYCOM values.* Accordingly, initial conditions in HYCOM were updated three times to correct the model bias. After the assimilation of MODAS sea surface temperatures, pre-Isidore SSTs agreed well with the data over most of the domain (Fig. 2b). Notice that the west Florida Shelf was cooled

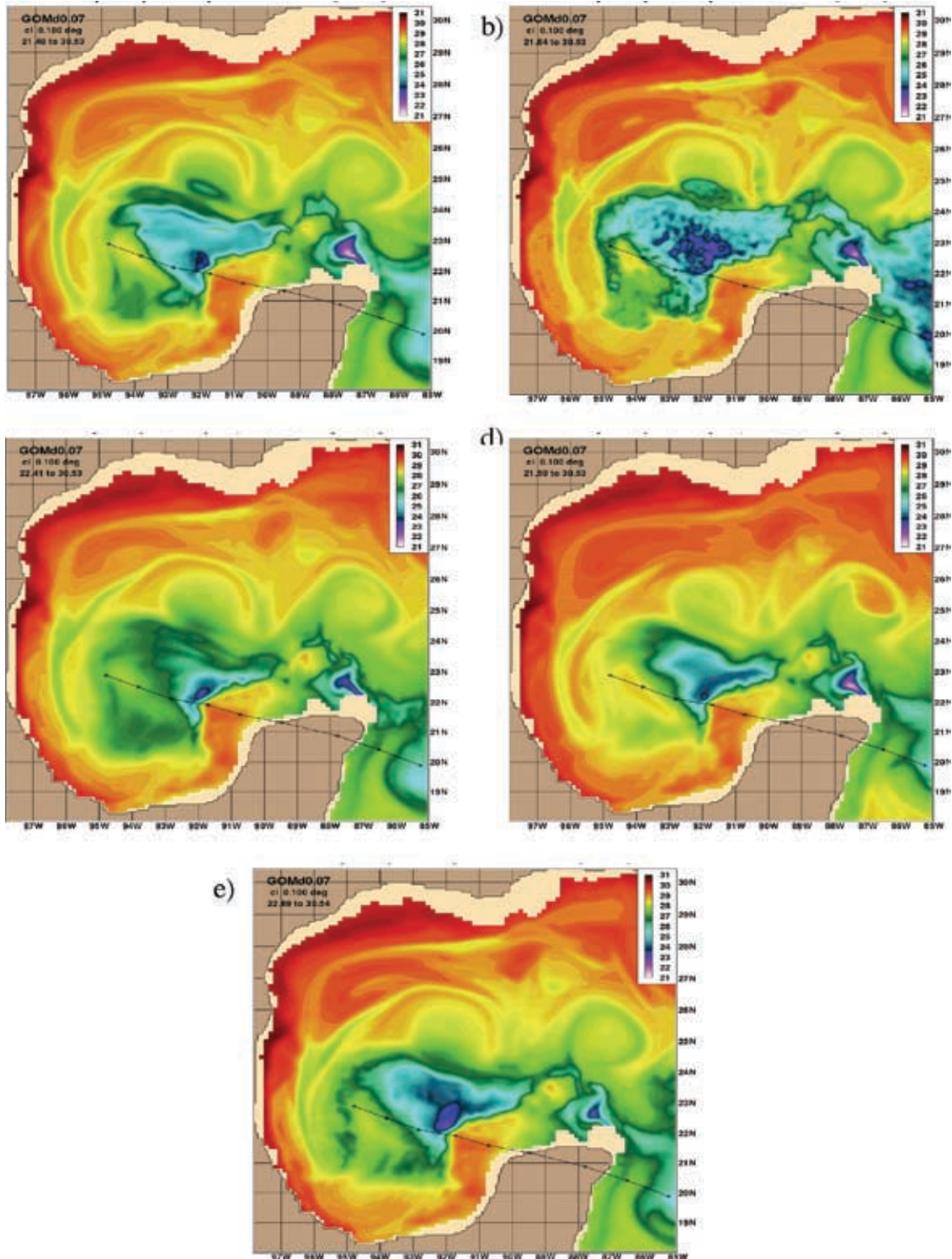


Figure 1: Simulated mixed layer temperatures during hurricane Gilbert for mixing schemes a) K-Profile Parameterization, b) Price-Weller-Pinkel c) Kraus-Turner d) Mellor-Yamada, and e) GISS. Differences between these five cases are visible with PWP being the coolest and KT being the warmest. Black line indicates track of the Storm at 06 GMT 16 Sept 1988.

by Tropical Storm Hanna about 10-days prior. Since both Isidore and Lili cases are combined into a single case, Lili pre-storm conditions are generated as part of the ocean response simulations.

Our research shows that shear-induced turbulent mixing usually accounts for most of the observed oceanic mixed layer cooling and deepening during hurricane passage away from warm frontal boundaries. This means that in order to increase our confidence in the vertical mixing scheme for predictive models, research flights must more routinely acquire current and shear data along with thermal structure. Eventually, the mixing scheme(s) that we select will be recommended for implementation at NCEP for their next-generation coupled hurricane model.

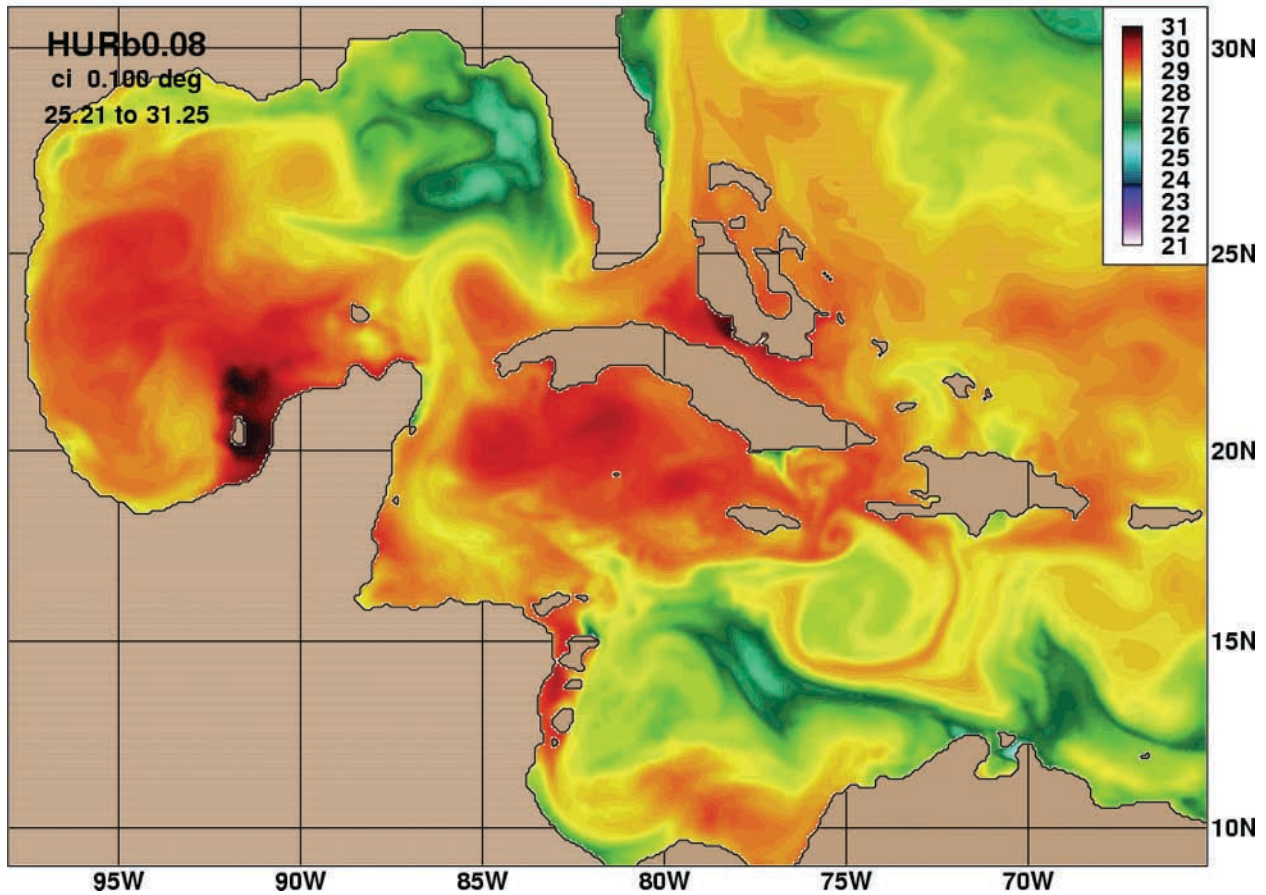
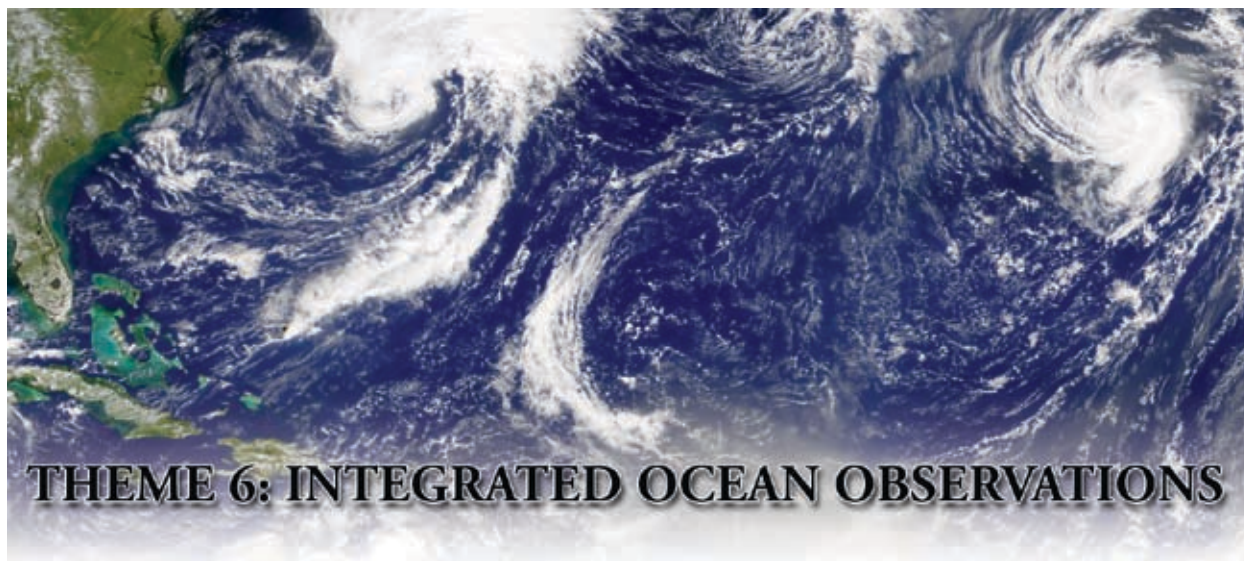


Figure 2: Observed and model simulated pre-Isidore temperature structure in the North-Western Caribbean Sea (left panel). Notice that SSTs are comparable to observations, however, 26°C and 20°C isotherm depths, climatology and model vertical thermal structures underestimate the oceanic heat content and the temperature gradient below the oceanic mixed layer. Pre-Isidore SST (right panel) is for a realistic initialization from the 0.08° North Atlantic basin-scale data assimilative HYCOM. Notice the cooling over the west Florida shelf induced by Tropical Storm Hanna approximately ten days before Isidore.



The ship based surface pCO₂ Program

K. Sullivan and H. Lueger (RSMAS/CIMAS); R. Wanninkhof (NOAA/ AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To constrain regional ocean CO₂ fluxes to 0.2 Pg C/yr.
- **Strategy:** To carry out sustained observations of pCO₂ using automated systems on volunteer observing ships.

CIMAS Research Theme:

- **Theme 6:** Integrated Ocean Observations
- **Theme 5:** Air-Sea Interactions and Exchanges (*secondary*)

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

The ship based surface pCO₂ program is designed to document regional oceanic carbon sources and sinks on a seasonal timescale by measuring surface water and marine boundary-layer pCO₂ on volunteer observing ships (VOS). The program contributes to the goal of creating regional flux maps on seasonal timescales to quantify uptake of anthropogenic CO₂ in the ocean and short-term changes thereof (Fig 1). The near-term focus is on development of the Northern Hemisphere ocean carbon observing system, which is closely linked to an assessment of the CO₂ sources and sinks over the coterminous United States through the North American Carbon Program (NACP). In FY-05 the NOAA-funded participants maintained instrumentation and reduced data from seven ships and posted the data. Flux maps, based on extrapolation routines using remotely sensed wind and sea surface temperature (SST) have been created for the Equatorial Pacific, and Caribbean.

Heike Lueger, a CIMAS post-doc, has applied novel extrapolation techniques along with a hydrographic province concept to determine CO₂ fluxes in the North Atlantic. Lueger has undertaken a new research effort as part of this project. Three provinces were identified for which different algorithms were created. The subpolar gyre is a province surrounding Iceland between Greenland and the tip of Scotland. Here we use chlorophyll and mixed layer depth data in addition to temperature to estimate the surface pCO₂. For the North Atlantic Drift province located in the eastern basin of the North Atlantic between 39° and 51°N, 10° and 43°W, two algorithms were developed to match the summer and winter seasons. In the summer time SST and chlorophyll data are used in a polynomial algorithm with an accuracy of 8 µatm. From September to June a linear relationship between SST and chlorophyll was used to estimate the seawater fCO₂ and yielded the same accuracy. The Gulfstream

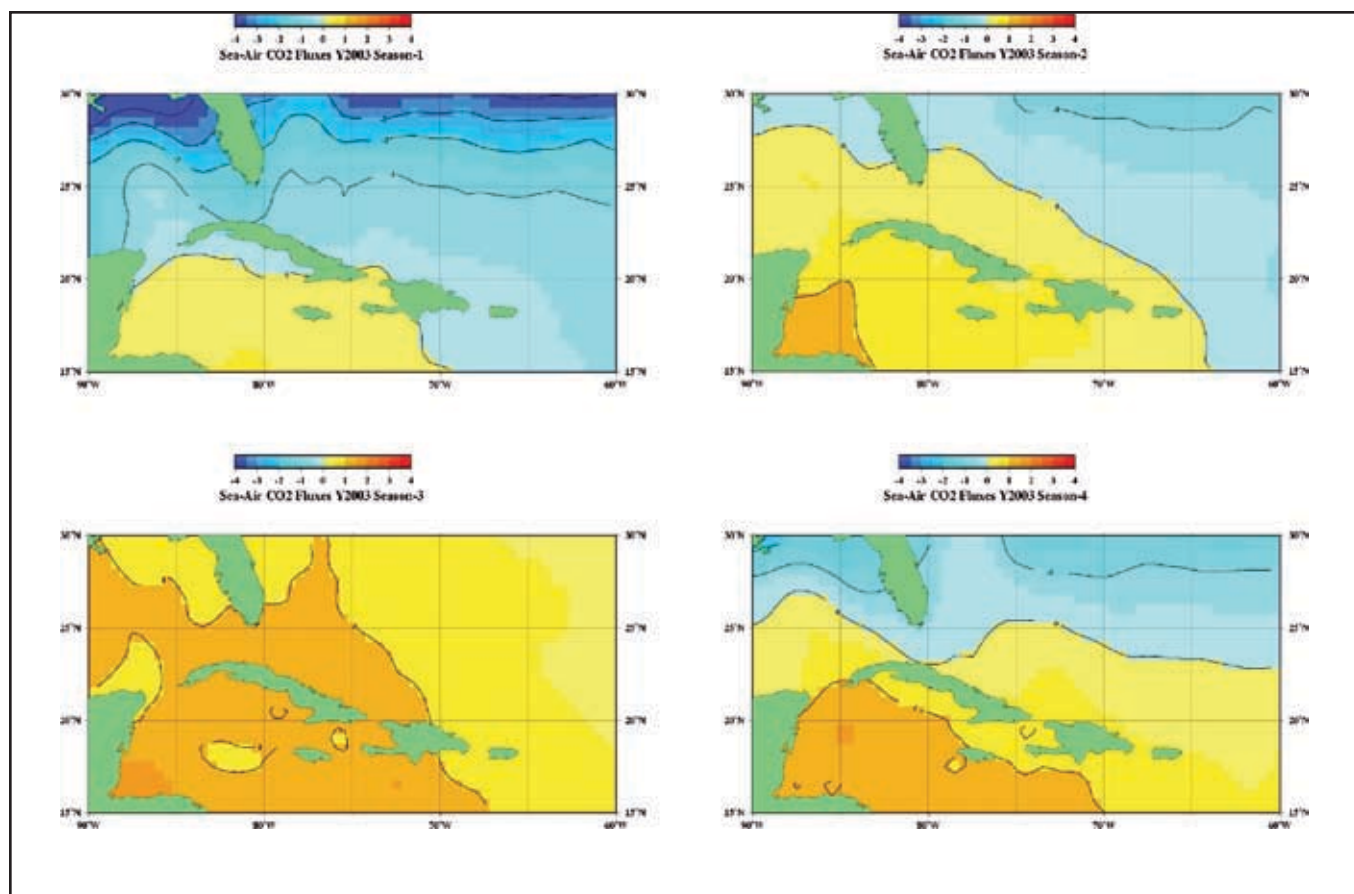


Figure 1: Seasonal flux maps for the Caribbean Sea for 2003 based on observations of one of the volunteer observing ships, the Explorer of the Seas and algorithms using remotely sensed SST.

province is mainly a temperature-controlled region as it is part of the subtropical gyre. Therefore a year-round algorithm was created which used SST in a second-order polynomial and it yielded an accuracy of 10 μatm . These algorithms are validated by independent data that are also retrieved from VOS in order to estimate how well these algorithms work.

Research Performance Measure: We have achieved our major objective: to create CO_2 flux maps for the Caribbean Seas, Equatorial Pacific and North Atlantic.

Cooperative Sensor Development Laboratory for Oceans and Climate

G. Hitchcock, (UM/RSMAS); R. Wanninkhof (NOAA/AOML);

R.H. Byrne and E. Kaltenbacher (U. South Florida)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To develop new and improved autonomous CO_2 sensors for a global ocean carbon observing network.
- **Strategy:** To work collaboratively with the Center of Ocean Technology of the University of South Florida and NOAA partners to develop and field test a new generation of spectrophotometric sensors for high accuracy measurement of CO_2 system parameters.

CIMAS Research Theme:

- **Theme 6:** Integrated Ocean Observations
- **Theme 5:** Air-Sea Interactions and Exchanges (*secondary*)

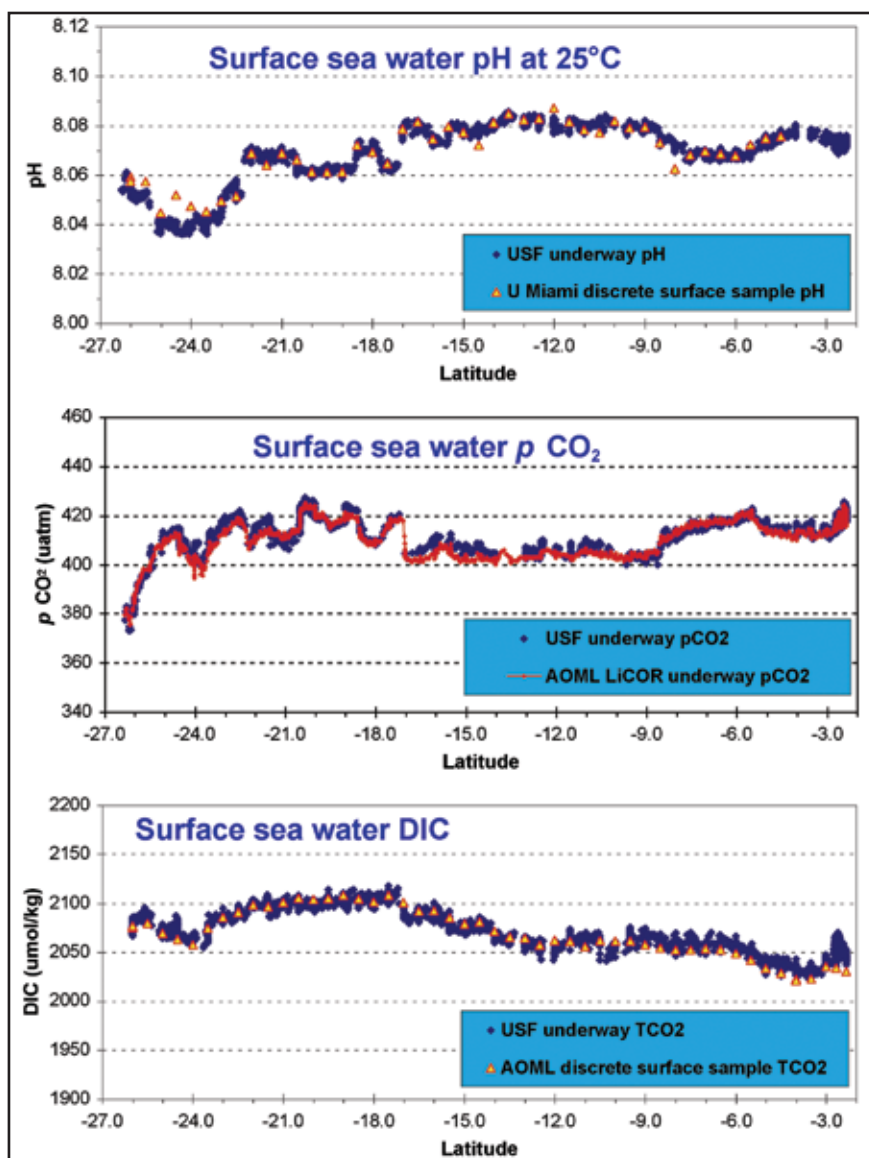
Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

In order to build a robust and efficient global ocean carbon observing system to monitor the uptake of anthropogenic CO_2 into the ocean, it will be necessary to significantly enhance our ability for autonomous measurements.. In this effort we have partnered with Center of Ocean Technology of the University of South Florida, the premier development laboratory for inorganic carbon parameters in the ocean, to develop and test novel autonomous CO_2 sensors as well as sensors for ancillary parameters such as oxygen and nutrients.

Our major effort focuses on developing shipboard CO_2 measurement systems for continuous measurements of total dissolved inorganic carbon, dissolved inorganic carbon (DIC) and total alkalinity. These spectrophotometric-based measurements have been directly compared with accurate discrete measurements obtained by NOAA/AOML and U. Miami personnel using conventional techniques on CO_2 /CLIVAR repeat



hydrography cruise A16S. (See Figure 1). Our continuous measurements show excellent agreement with discrete DIC measurements obtained coulometry by NOAA/AOML personnel and pH measurements obtained by the group of the University of Miami.

We are also developing *in situ* measurement systems for observations of pH, pCO₂ and DIC. We are also working to expand the CO₂ measurements to include macronutrient (nitrate/nitrite, phosphate, silicate) measurements using a similar spectrophotometric technique.

In addition, as part of this project work has been performed on testing a new generation oxygen sensor (Optode). Oxygen can be used quantitatively in carbon cycle research together with DIC to determine biological productivity and air-sea gas exchange. Two forms of O₂ sensors are now being field tested. One is a commercially available oxygen optode produced by Aanderaa Instruments. One initial result from a long-term (weeks) test in flowing Biscayne Bay seawater confirms a recently published evaluation made by the Alliance for Coastal Technologies:

http://www.act-us.info/Download/Do_Evaluations/ACT_VS04-01_Aanderaa_DO.pdf.

The probe meets accuracy and precision as specified by the manufacturer, however, fouling of the probe occurs in surface subtropical seawater after a few weeks. A test is underway with an anti-foulant to determine if a longer deployment is feasible in subtropical surface waters. A second probe is being deployed as an *in situ* productivity sensor. This instrument measures changes in dissolved O₂ over 12 hour periods in successive day-night periods to derive net community productivity and dark community respiration rates, respectively. The test is being conducted in Sarasota Bay, a region affected by the Florida red tide organism *Karenia brevis*, on an instrumented platform maintained by the Mote Marine Laboratory

Research Performance Measure: All aspects of the research and development program are on track.

Atlantic High Density XBT Lines

Q. Yao, P. DiNezio, L. Gramer, C. Fonseca, R. Garcia, B. Kates,
G. Rawson and N. Melo (UM/CIMAS); M. Baringer, G. Goni,
S. Garzoli, C. Thacker, and C. Lumpkin (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them.

- **Objectives:** To study the upper ocean thermal structure and associated ocean dynamics and estimate the poleward temperature transport in the Atlantic Ocean.
- **Strategy:** To measure the upper ocean thermal structure in the center of the subtropical gyre in the North Atlantic and South Atlantic Ocean using high-density XBT lines and to combine these observations with those from other platforms, such as satellites, floats, drifters and moorings, to enhance the global ocean observing system.

CIMAS Research Theme:

- **Theme 6:** Integrated Ocean Observations
- **Theme 1:** Climate Variability (*secondary*)

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

This program is designed to measure the upper ocean thermal structure in key regions of the Atlantic Ocean (Figure 1). The seasonal to interannual variability in upper ocean heat content and transport is monitored to understand how the ocean responds to changes in atmospheric and oceanic conditions and how the ocean response may feedback to the important climate fluctuations such as the NAO. This increased understanding is crucial to improving climate prediction models. Within this context, five XBT lines have been chosen to monitor properties in the upper layers of the Atlantic Ocean. The global atmospheric and oceanic data from Ships of Opportunity (SOOP) have been the foundation for understanding long-term changes in marine climate. This program is a component of the NOAA's Program Plan for building a sustained Ocean Observing System for Climate and directly addresses one of its milestone: *occupy 41 volunteer observing ship (VOS) lines for high accuracy upper ocean and surface meteorological observations, by 2007.*

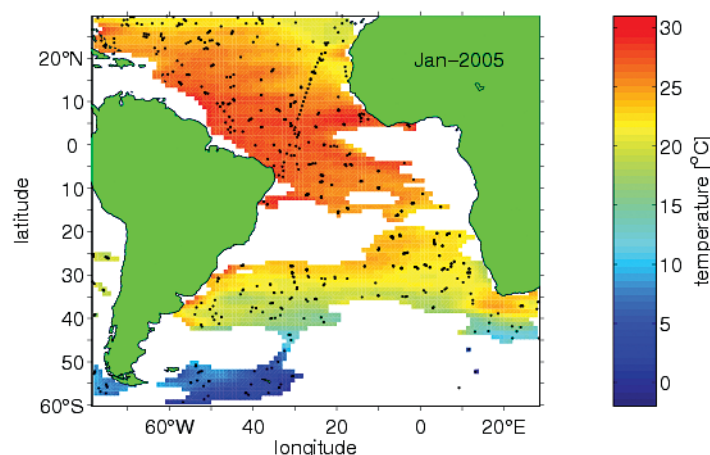


Figure 1: Map of station locations for the five high density lines maintained by NOAA/AOML.

Global Drifter Center Data Assembly Center (DAC)

J. Redman (UM/CIMAS); R. Lumpkin and M. Pazos (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To collect and validate data from the Global Telecommunications System (GTS) and provide for its dissemination; to provide uniform quality-controlled data from the historical data sets of sea surface temperature (SST) and surface velocity.
- **Strategy:** To monitor on a daily basis GTS sensor failure and removes these sensors from the GTS; to places newly deployed drifters onto the GTS; to create global population maps showing drogued and undrogued drifters. To made DAC data promptly available on the web.

CIMAS Research Theme:

- **Theme 6:** Integrated Ocean Observations

Link to NOAA Strategic Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

The DAC works closely with researchers to provide high-quality drifter data in a rapid and accessible manner. The DAC has four primary **objectives**: GTS distribution, quality control, web access, and performance evaluation. The DAC inserts and deletes drifters onto the GTS. The accuracy of data is monitored and drifters are removed once sensors fail. The DAC also notifies Argos of drifters that have lost their drogue so that this information can be noted in the GTS message.

The DAC decodes raw data that is received from Argos and applies calibrations. New drifters are identified and deployment times and positions determined. Drifters that have stopped transmitting are identified and last good time and position is determined. Drogue off day is also determined. The DAC then compares the drifter's SST with Reynold's climatology to determine the last good day for the SST sensor. Bad SST's and positions are removed and data is interpolated to six-hour intervals using Kriging method. The DAC inserts this interpolated data in the NOAA/AOML database for web access. Database updates are periodically sent to MEDS for archiving and distribution.

Various web products are also updated weekly. New this year are Global Distribution Maps that include drogue status and 90-day forecasts, which will aid in the study of mixed layer currents. To ensure that these currents are properly studied, the DAC is also reviewing the drogue loss dates of drifters over the past six years. We are correcting any errors, keeping a log of all changes, and making the correct dates and changes available to the scientific community. We are also aiming at reaching a population goal of 1250 actively observing drifters by the end of September 2005.

Research Performance Measure: All goals were met during this year.

Coral Reef Early Warning System (CREWS) Project

J. Absten, L. Florit, M. Jankulak and D. Manzello (UM/RSMAS);

J. Hendee, M. Shoemaker and J. Craynock (NOAA/AOML);

J. Judas (NOAA Corps); E. Stabenau (NOAA/NRC)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To facilitate in-situ observations at coral reef areas so as to better understand the physical processes that might be affecting the health of the reef system.
- **Strategy:** To construct meteorological and oceanographic monitoring platforms near coral reef areas, and to provide data archiving and artificial intelligence tools that can facilitate the acquisition of high-quality data and enable the rapid assessment of the physical environment at these areas.

CIMAS Research Theme:

- **Theme 6:** Integrated Ocean Observations

Link to NOAA Strategic Goals:

- **Goal 1:** Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management.
- **Goal 3:** Serve Society's Needs for Weather and Water Information.

Research Summary:

Through continuous data collection and real-time monitoring, CREWS provides scientists and managers with data critical to understanding the complex physical, chemical, and biological processes influencing coral reef ecosystems. CREWS stations are currently installed at North Norman's Reef near the Island of Exuma, Bahamas, and at Salt River, St. Croix in the U.S. Virgin Islands, with plans for additional stations in the Caribbean and Pacific regions. For the 2004-2005 year, the project has centered its efforts around the implementation of a new structural hardware design focused on improving the stability and reliability of the instrumentation at the study sites. Of particular note is the successful implementation of a long-term coral PAM Fluorometry observation system at the North Norman's Reef station. This system is unique in that it is the only instrument that provides a direct measure of coral health that can be correlated with remotely measured environmental conditions. The CREWS expert system combines the PAM Fluorometer data with other station observations (from instruments such as pCO₂ sensors, multi-spectral light instruments, temperature loggers and others) to predict conditions conducive to coral bleaching events. The expert system reports are then distributed via the Coral Health and Monitoring Program website located at <http://www.coral.noaa.gov> and email. Continuous baseline data collection, combined with real-time monitoring tools allow scientists, modelers and managers to understand the processes that drive coral reef ecosystems and provide the necessary information to properly manage and protect these unique and valuable natural resources.

Research Performance Measure: All objectives were reached.



Fig. 1- Installation of the newly designed CREWS monitoring station near the Perry Institute for Marine Science on Lee Stocking Island,



Fig. 2- Scientists install a PAM fluorometer on a hard coral *Agaricia* sp.

The CLIVAR CO₂ Repeat Hydrography Program

K. Sullivan, C. Fonseca, B. Kates and G. Berberian (UM/CIMAS);
C. Langdon (UM/RSMAS); R. Wanninkhof and M. Baringer (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To constrain regional ocean CO₂ inventories to 2 Pg C/ decade.
- **Strategy:** To reoccupy transects on a decadal timescale to quantify the uptake of anthropogenic CO₂ by the ocean.

CIMAS Research Theme:

- **Theme 6:** Integrated Ocean Observations

Link to NOAA Strategic Goals:

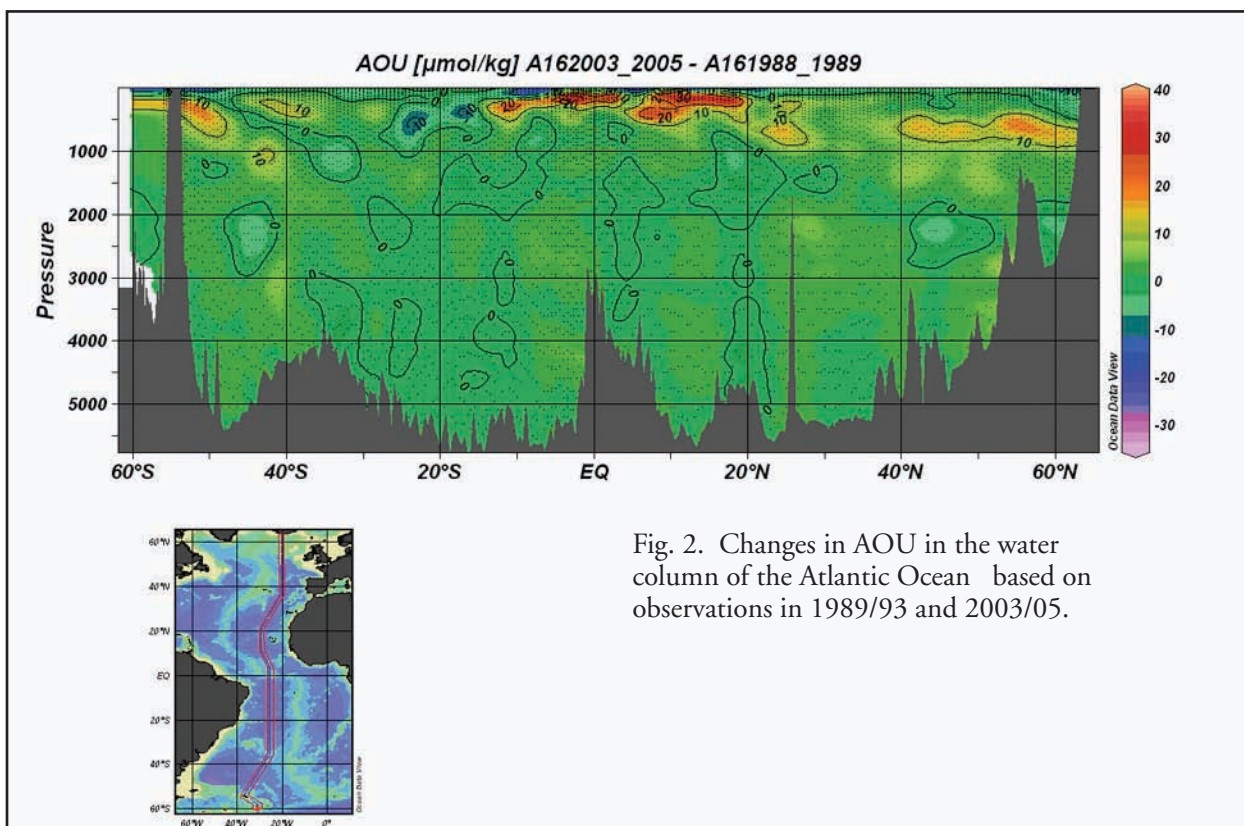
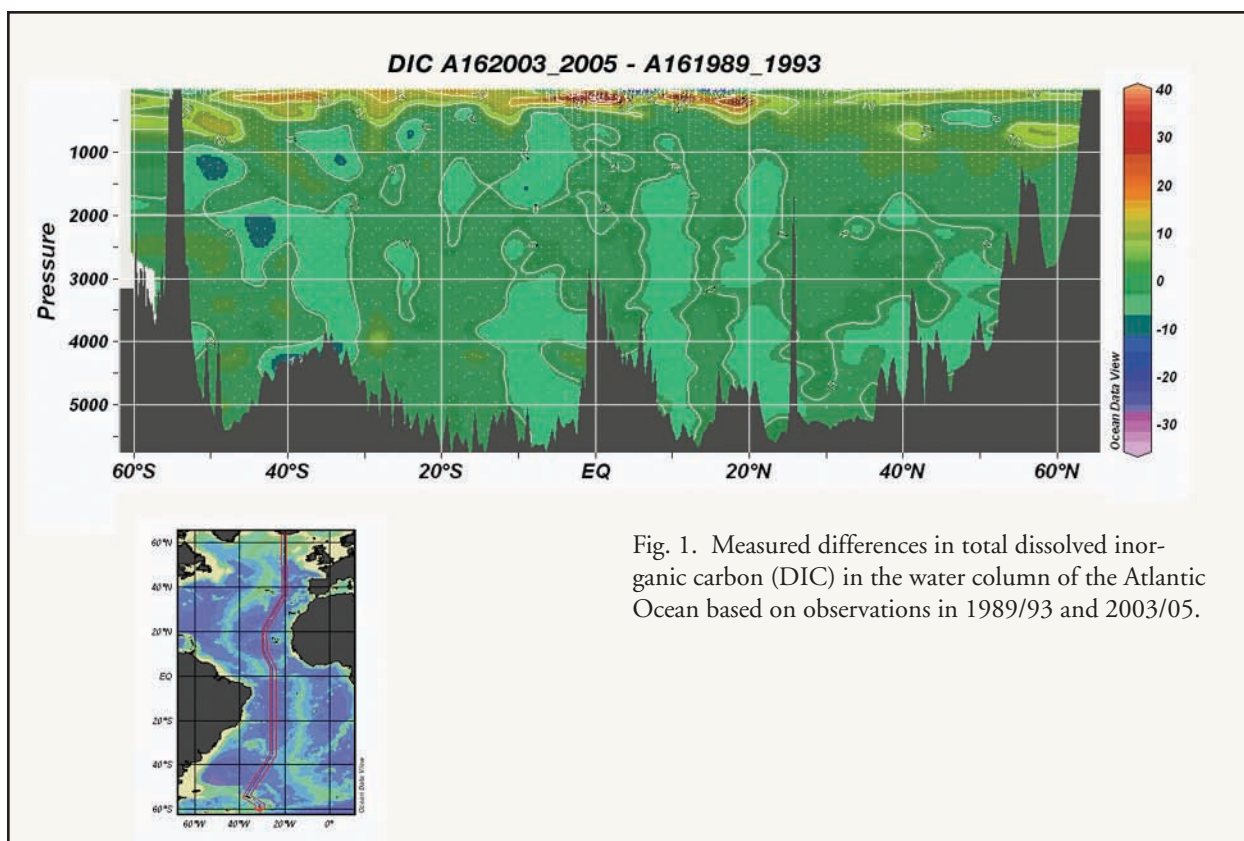
- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

The CLIVAR CO₂ Repeat Hydrography Program is a global re-occupation of select hydrographic sections to quantify changes in storage and transport of heat, fresh water, carbon dioxide (CO₂), oxygen, chlorofluorocarbon tracers and related parameters. Data from these cruises will be compared to data from previous surveys (e.g., World Ocean Circulation Experiment (WOCE)/Joint Global Ocean Flux Survey (JGOFS) during the 1990s) to measure changes in the physics and biogeochemistry of the oceans and to determine where atmospheric CO₂ is entering the oceans on decadal timescales. The program is designed to assess changes in the ocean's biogeochemical cycle in response to natural and/or man-induced activity. Global warming-induced changes in the ocean's transport of heat and freshwater, which could affect the circulation by decreasing or shutting down the thermohaline overturning, can be followed through long-term measurements. The program will also provide data for continuing model development that will lead to improved forecasting skill for oceans and global climate. For FY-2005 a meridional line in the South Atlantic was occupied from 60° S to 3° S with full physical and chemical characterization of 120 water column profiles.

Combined with data from the 2003 cruise we can now, for the first time, accurately quantify the changes in the water column in the Atlantic basin since the WOCE cruises that occupied the lines in the late 80's and early 90's. Changes in dissolved inorganic carbon (DIC) and apparent oxygen utilization (AOU) are most pronounced in the upper 1000 m water column. DIC changes range from -5 to +40 μmol/kg and AOU changes by a similar amount. AOU increases of similar magnitude as increases in DIC point towards a significant contribution of oxidation of organic matter to the DIC increase, the remainder is attributed to the anthropogenic CO₂ increase. The large changes in biogeochemical properties of the upper water column of the Atlantic have been one of the big surprises in the decadal reoccupation of the transects.

Research Performance Measure: Quantify the decadal increase of CO₂ in the Atlantic Ocean to 2 Pg C.



US Argo Project: Global Ocean Observations for Understanding and Predicting Climate Variability

X. Xia, E. Forteza, and H. Yang (UM/CIMAS); R.L. Molinari,
C. Schmid, R. Sabina, Y.-Ho Chong Daneshzadeh (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To improve our understanding of interannual to multidecadal ocean variability and its role in climate.
- **Strategy:** To monitor ocean parameters over large areas of the ocean through the deployment of 1500 profiling floats as a part of a global array of 3000 floats.

CIMAS Research Theme:

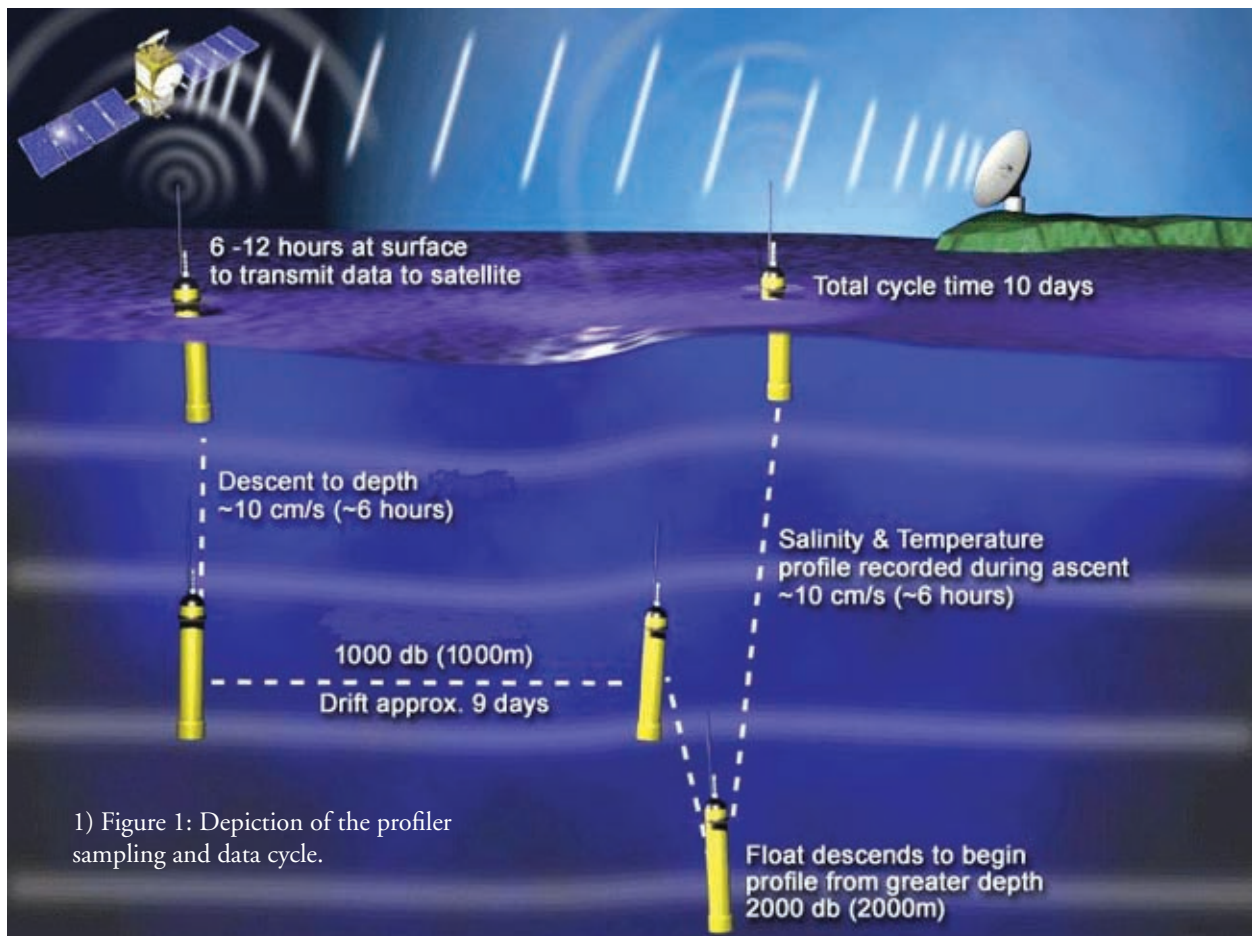
- **Theme 6:** Integrated Ocean Observations

Link to NOAA Strategic Plan Goal:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

The Argo array is part of the Global Climate Observing System/Global Ocean Observing System (GCOS/GOOS). Argo profilers provide measurements of temperature, salinity and currents to depths of 1000-2000 meters. Researchers in many scientific disciplines, including meteorology, climatology and oceanography, use data collected from the floats. The Argo array will eventually consist of a total of 3000 profilers. Figure 1 shows how the profilers function.



1) Figure 1: Depiction of the profiler sampling and data cycle.

The US Argo Data Assembly Center (US DAC) at AOML is responsible for deploying floats, acquiring and processing the data. The US DAC has developed and maintained an automatic system for decoding, quality control, and distribution of data obtained from the US Argo floats in real-time. The system runs in a 24/7 mode. The data is open to the public, in particular is being used by scientists working on climate models and oceanographic data analysis. Some of this year accomplishments are:

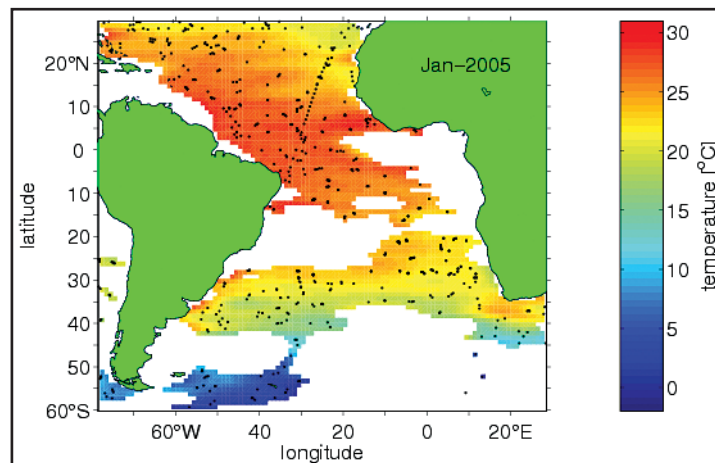
- 526 floats were deployed
- 118 floats were deployed by AOML
- 1000 floats are actively reporting
- US DAC is processing 108 Argo-equivalent floats (i.e. not funded by Argo) from different institutions and organizations (Florida State University, NAVOCEANO, University of Hawaii and National Buoy Data Center)

The US DAC is maintaining a website (<http://www.aoml.noaa.gov/phod/ARGO/HomePage>) that provides documentation and information about the operations at the US DAC.

Data from Argo floats are used to derive the mixed layer heat balance in the Atlantic Ocean, currently in the latitude range 40°S to 35°N. Monthly estimates of the heat storage rate are derived from all hydrographic profiles, including Argo profiles. These monthly fields are analyzed in conjunction with surface fluxes and oceanic heat transports. This will provide valuable insights into regional differences of the heat balance. It will also help to better understand the causes for the seasonal to inter-annual variability observed in the ocean and atmosphere. Preliminary results are shown in Figures 2,3 and 4. Figure 2 shows the mixed-layer temperature for January 2005. Figure 3 shows the mixed-layer thickness for January 2005. Figure 4 shows Heat storage rate ($c_p h \partial T / \partial \tau$) from the mixed layer properties for January and February 2005.

Quality controlled Argo profiling data are also used to calibrate thermosalinograph (TSG) data. Float data have to be measured within one week and 200km distance from the TSG measurement for this purpose.

Research Performance Measure: This program has attained all objectives and has met all time schedules. It continues to operate as planned.



2) Figure 2, Atlantic mixed layer temperature, January 2005.

AOML Environmental Data Server

X. Xia (UM/CIMAS); R. Sabina (NOAA/AOML)

Long Term Research Objectives and Strategy to Achieve Them:

- **Objectives:** To facilitate the access and retrieval of environmental data hosted at Atlantic Oceanographic and Metrological Laboratory (AOML).
- **Strategy:** To provide Web-based access to datasets hosted at AOML.

CIMAS Research Theme:

- **Theme 6:** Integrated Ocean Observations

Link to NOAA Strategic Plan Goals:

- **Goal 2:** Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond.

Research Summary:

The project supports the capabilities of NOAA as a National global resource service. It facilitates easy web access to data. By making more datasets available such as Global Ocean Observing System (drifter buoys and XBT) in near real-time and delayed-mode, we are supporting the NOAA Climate Strategy.

Ocean observing systems operated by NOAA's Global Ocean Observing System, housed in AOML Physical Oceanography Division (PHOD), provide data and metadata to be loaded and updated into respective databases from research and merchant ships, surface drifters and profiling floats. For instance, the US Argo Data Assembly Center is processing the real-time Argo floats data, to allow for real-time monitoring of the floats, data and various visualization products are used. These products rely on the Argo real-time database. It loads daily Argo float data including metadata and profile data into the database. NOAA's XBT program (SEAS) currently supports about eighty voluntary observing ships (VOS). Observations from these vessels are collected and coded using the WMO bathy report format (JJYY) and transmitted via the GOES and INMARSAT C satellites. SEAS vessels are responsible for more than 14,000 XBT observations each year. To monitor the performance of the XBT instruments, real-time quality control of SEAS XBT data is performed at AOML, the quality controlled data are populated into AOML database and served via web. Satellite-tracked drifting buoy data are being collected by numerous investigators and agencies in several countries for the World Ocean Circulation Experiment-Tropical Oceans Global Atmosphere (WOCE-TOGA) Surface Velocity Program. This global dataset will provide the climatology and chronology of the surface currents of the World Ocean. To expedite completion of research quality datasets for archival and dissemination, the global drifter data is served to the scientific community. The data server also hosts hurricane related data such as synoptic data that reflects wind and pressure intensity estimates for ship and land stations of the Atlantic basin.

We provide guidance to customers and answer customers' questions on how to retrieve the data they are interested and other software related issues. The Server provides easy access to environmental data for scientists to study various issues related to seasonal to interannual climate forecasts, ocean circulation, data assimilation and numerical models, etc. Web statistics shows high usage by people around the world.

The data server's URL is: <http://db.aoml.noaa.gov/dbweb>

Research Performance Measure: This program has attained all objectives and has met all time schedules. It continues to operate as planned.

OUTREACH

The Rosenstiel School and CIMAS are active in education and outreach at the undergraduate and high school level. We are also involved with outreach to the general public. Many of these activities take place in cooperation with the local NOAA laboratories. Here we present a brief overview of outreach activities at the School in which CIMAS is involved. We only list those activities that describe on-going activities that follow a specific theme. There are many other outreach activities that are one-time events such as presenting talks to students, to groups of special-interest adults (e.g., fisherman), conducting tours, preparing articles for various media, etc. We do not list those here. Also many CIMAS personnel are active in setting up and maintaining web sites at AOML and SEFSC that perform an outreach function. We do not list these here.

Explorer of the Seas Programs

The Rosenstiel School and Royal Caribbean Cruise Lines (RCCL) with support from NOAA and NSF, and with the close cooperation of NOAA and CIMAS scientists are engaged in a unique collaboration to study the ocean and atmosphere during routine cruises of the RCCL ship Explorer of the Seas. <http://www.rsmas.miami.edu/rccl/>

Explorer is a new state-of-the-art cruise ship (142,000 tons, 1020 feet LOA, 157.5 ft beam; 3114 passengers; cruising speed, 23.7 kts) which started operations out of Miami in October 2000. Each week the Explorer cruises across the Gulf Stream to ports in the Caribbean and the Bahamas. RCCL provides free-of-charge two science laboratories (installed at RCCL's expense) to RSMAS and AOML, an atmospheric sciences laboratory and an oceanographic laboratory. Laboratory instrumentation was obtained with funds provided by RCCL, NOAA, and NSF. RCCL also provides at no charge two passenger cabins for RSMAS, AOML and visiting scientists and technicians. All data are made available to the general scientific community and to the public.

CIMAS and NOAA Research on the Explorer

The ship carries a wide range of instrumentation that allows continuous unattended measurements of a wide range of ocean and atmospheric properties. Data is returned via various communication links to data centers at RSMAS, National Weather Service, NOAA's National Data Buoy Center at Stennis Space Center, and the GLOBE (Global Learning and Observations to Benefit the Environment) program. A number of research programs supported through CIMAS make use of the Explorer as described in this annual report. The program is designed to facilitate the participation of scientists outside the UM and NOAA communities as described on the Explorer web site. <http://www.rsmas.miami.edu/rccl/participate.html>

Outreach Aboard the Explorer

The research facilities were designed to facilitate observation and educational activities by the vacationing passengers. The passengers can observe data being collected in real time. Also all scientists who participate on the one-week cruises must provide one or more lectures to the passengers. Educational materials are provided to passengers as well. Scientists from the local NOAA laboratories and from RSMAS-CIMAS routinely participate on these cruises and lead the outreach activities.

Miami-Dade County Scientist-Teacher Mentor Program.

During the past year, RSMAS initiated a new program in conjunction with the Miami-Dade Public School System and Royal Caribbean.: The Scientist-Teacher Mentor Program. http://www.rsmas.miami.edu/rccl/miamidade_teacher.html

Teachers apply for 6 annual spots in the program by writing a proposal that describes research that they would like to perform on the Explorer. The program consists of familiarization workshops onboard the Explorer of the Seas and at RSMAS. Teachers then participate in a seven day cruise on the Explorer during which they perform the research activities outlined in their proposal. Teachers must submit a post-cruise summary of their activities in the program, a curriculum module with separate classroom lessons developed from your research onboard.

Ongoing real-time data can be provided for use in the classrooms year-round. In addition, teachers are expected to present their experiences and resulting lessons at a local, regional or national educator conference or meeting within 12 months after their cruise.

The MAST Academy and High School Student Outreach

Starting in 1984 the Rosenstiel School and CIMAS have participated in a high school apprenticeship program made possible through NOAA funding. Students participate in summer internships at AOML and SEFSC. This activity is carried out through a Miami-Dade County “magnet” school, the MAST Academy (Maritime and Science Technology High School) which is located on Virginia Key, only a few hundred meters from CIMAS and the NOAA laboratories. <http://mast.dade.k12.fl.us/>

The MAST Academy curriculum is organized around a marine theme. The school has been recognized by the U. S. Department of Education with a Blue Ribbon School of Excellence and by Business Week magazine as one of seven most innovative schools of choice in the nation. The total enrollment is 550 in grades 9-12. The school has a broad cultural-ethnic mix of students: 36% Caucasian; 32% African American; 29% Hispanic; 3% Asian. Approximately 94% of the students eventually enroll in college. MAST students excel according to traditional measures of student performance, exceeding national averages on the PSAT, SAT, and ACT. For the past three years, the school has received an “A” rating from the Florida Department of Education.

RSMAS participates in education-related activities at MAST by providing faculty and graduate students, including CIMAS-linked personnel, to deliver lectures and to teach courses. Every summer, 12-18 students are selected to participate in summer research programs supported through CIMAS. The students assist in programs at AOML and SEFSC as well as at RSMAS. In addition to the summer program, CIMAS hires MAST students during the course of the year. As a result of these activities MAST students have co-authored papers with RSMAS and NOAA scientists; students have attended national conferences and presented the findings of their research. They have participated in field programs, for example in a comprehensive study of Biscayne Bay. In this way, we have developed a solid working and teaching relationship with the MAST Academy

In addition to MAST students, we have students from other high schools participating in CIMAS - NOAA activities. Here we cite a few examples:

- Assisted in SEFSC fish tagging program. Prepared tagging kits for distribution to fishery constituents, coding incoming tagging data, data entry of both tag release and tag recapture, and interacting with constituents about tag requests and tag recovery reports.
- Assisted in sorting and identifying postlarval pink shrimp from the Florida Bay program and working with bird by-catch data.
- Assisted in downloading sea-surface temperature (SST) data from the NOAA Coast Watch web site and using it in analyses of fisheries and environmental data.
- Assisted in a study modeling connections between life stages and habitats of pink shrimp in South Florida.
- Assisted in using bioinformatics software in a study to identify, detect, and quantify microbial contaminants in coastal waters. A second student worked on the development of a microbial contaminant database using FileMaker Pro Software.

Undergraduate Student Education

CIMAS hires undergraduate students from the University of Miami and other local universities who work part time on projects at AOML and SEFSC. This program has been effective in exposing bright students to the scientific working environment. Some of these students have subsequently gone on to graduate school at RSMAS and other institutions and some have been eventually hired as full time employees. Some examples:

- During the past year, five students participated in the SEFSC-CIMAS program: Monitoring Coral Reef

Fish Utilization of MPAs and Recruitment Connectivity between the Florida Keys and Meso-American Reefs. Six students were from UM, one from Florida International University (FIU) and one from Miami-Dade College. One of these students will go on to graduate school at Stanford. Another student from ECOSUR used a part of his work for his senior thesis.

- Several UM undergraduate students participate in the bi-monthly cruises that take place as a part of the program: Long-Term Measurement of Physical, Chemical, and Biological Water Column Properties in the South Florida Coastal Ecosystem
- An undergraduate student from FIU participates in the program: Demographic monitoring of *Acropora palmata* in the Florida Keys

Global Ocean Surface Current Web Outreach

CIMAS provides partial support for a web site that presents information of ocean surface currents. The site, still under development, is designed to provide students with general information about oceanography but with a specific focus on ocean currents. The current information is derived from a data-assimilative hybrid isopycnal-sigma-pressure (generalized) coordinate ocean model (called HYbrid Coordinate Ocean Model or HYCOM). HYCOM is a multi-institutional effort funded by the National Ocean Partnership Program (NOPP), as part of the U. S. Global Ocean Data Assimilation Experiment (GODAE). A web-based reference site on ocean currents intended for students is accessible at <http://oceancurrents.rsmas.miami.edu>. The site contains introductory material for the non-specialist, a glossary, descriptions of named currents, etc.

A critical problem in ocean modeling and data assimilation is making both the observational data and model output available to (a) the members of our consortium for HYCOM and data assimilation code development, (b) the wider oceanographic and scientific communities, including climate and ocean ecosystem researchers; and (c) the general public. We are making a special effort to create modules that appeal to students in elementary and high school. The real-time global and basin model outputs are being made available to the community at large within 24 hours via the U.S GODAE and Miami Live Access Servers (LAS). The web activity is under the direction of Dr. Arthur Mariano (RSMAS, Div. Meteorology and Physical Oceanography).

University of Miami, a Minority Serving Institution

The National Oceanic and Atmospheric Administration (NOAA) has established research and education centers to advance the community of under-represented minority scientists in the US and, especially, in the NOAA workforce. The UM participates in this program carried out under the lead of Florida A & M University (FAMU) through the Environmental Cooperative Science Center (ECSC). The Center is funded through a cooperative agreement between NOAA and FAMU. Other partners are Morgan State University, Delaware State University, South Carolina State University and Jackson State University. Located on the campus of FAMU, the science center was established to study and address ecological and coastal management issues. So far, the science center has supported more than 130 students in the environmental and marine sciences.

The goals of the science center are to increase the number of underrepresented minority scientists in NOAA-related sciences, develop ways to monitor coastal ecosystems and assess impacts of human and natural actions, improve the scientific knowledge base used in coastal resource management, and facilitate community education and outreach relating to coastal ecosystems. The Center was started in 1995 and was recently renewed with NOAA in late 2004.

The central research themes of ECSC focus on the human environment interactions involving the coastal environment and the development of conceptual models of those interactions.

- to develop the next generation of MS and PhD-level scientists in the environmental sciences from under-represented minorities, especially African-Americans, Hispanic-Americans, and American Indians;
- to develop research activities on coastal environmental issues, focused on a set of NOAA National Estuarine Research Reserve (NERR) sites, plus the Florida Keys National Marine Sanctuary (FKNMS); and

- to conduct institutional capability building in the partner Historically Black Colleges and University (HBCU) institutions (e.g., graduate degree programs).

The Rosenstiel School's roles are:

- to provide fellowships for minority students for MS and PhD studies at RSMAS in environmental science and policy fields;
- to provide ship and other field experiences for undergraduate students;
- to assist in developing distance-learning classes in environmental sciences;
- to assist in the capacity building at partner institutions; and,
- to serve as the linkage to Florida Keys Sanctuary.

Many of the RSMAS activities associated with this program are carried in the context of CIMAS-related programs.

The “Bonefish Census”

Bonefish are fast-moving predators that dwell in the clear, shallow tropical waters of South Florida. They are regarded as a premier game fish because of their elusiveness and because when hooked they put up a fierce fight. They may be found in tropical waters worldwide but thrive in the Florida Keys, where most of the world records have been set. Bonefishing is economically important to the Florida tourist industry. Sport fishing contributes more than \$2 billion to the Florida economy and a large fraction of that comes from bonefishing. But little is known about the status of bonefish populations. Evidence suggests that populations have declined sharply in recent decades.

In order to learn more about bonefish, RSMAS and CIMAS scientists initiated an annual program to carry out a bonefish census. The effort was led by J. Ault, Professor of Marine Biology and Fisheries at RSMAS and a CIMAS scientist, who also leads the university's Bonefish-Tarpon Conservation Research Project. The first census was carried out in the Florida Keys on October 2003 and the second census in October 2004; a third is scheduled for October 2005. A total of 65 fishing guides and anglers were split up among 19 zones stretching about 1,400 square miles from Biscayne Bay to the Marquesas Keys.

The objective was to establish a population baseline in support of conservation efforts. The census was a joint project of Bonefish and Tarpon Unlimited, the Florida Keys Fishing Guides Association, and RSMAS/CIMAS. It was endorsed by the Florida Keys National Marine Sanctuary and the National Park Service. The bonefish census activity is complementary to the intensive reef fish census activities that are carried out jointly by CIMAS and SEFSC scientists. On the basis of the census, we estimate the bonefish population at about 300,000. Based on money spent on boats, tackle and hiring guides to try to catch them, he says each fish is worth \$3,500 per year, or \$75,000 over its lifetime. Repeating the census annually helps to verify this data.

Monitoring Coral Reef Fish Populations in the Florida Keys:

Reef fish populations are monitored as a part of this CIMAS program, led by J. Ault, a RSMAS faculty member. The research carried out in this program is an excellent example of coordination, cooperation, and participation by different government agencies, universities, and private organizations to achieve a common goal. The research was documented in a number of media pieces including National Geographic, Los Angeles Times, BBC (British Broadcasting Company), NBC, Discovery Channel, Animal Planet, Chicago Tribune, Miami Herald, Associated Press, Christian Science Monitor, etc. In addition, Ault provided expert testimony before the Florida Governor and Cabinet at the Capital Building in Tallahassee, Florida, on approval of the Dry Tortugas National Park Research Natural Area.

Adopt-a-Billfish Program

The Adopt-a-Billfish program was established as a mechanism to enable science communication which would also facilitate partnerships with interested fishermen joint research efforts. The program is led by Robert Cowen, RSMAS./CIMAS. The program initially focused on RSMAS billfish pop-up satellite tagging efforts along the Pacific coast of Central America. The Billfish Research Initiative provides University of Miami's Rosenstiel School and CIMAS scientists and collaborating federal scientists of the National Marine Fisheries Service

Outreach

with the opportunity for an interdisciplinary, multi-faceted program to study the biology, environment and management of billfish within an ecosystem context. Main partners include individuals affiliated with the Presidential Challenge Central America (a group promoting catch-and-release fishing tournaments and other billfish conservation efforts), the NMFS' SEFSC and SWFSC, and the Bermuda Department of Environmental Protection. To date, the program has successfully tagged over 50 billfish along the Central American Pacific coast. This partnership has now expanded its geographical coverage to include Atlantic waters, and added another partner, The Billfish Foundation. An additional 50+ billfish (including sailfish, blue and white marlin) have been successfully tagged as a result of this program. Results of the movement trajectories of electronically tagged animals are made available to the participants and other interested parties, and presentations of the study are regularly made to fishing clubs that operate from Panama, Puerto Rico, Dominican Republic, Bahamas, and throughout the United States. The costs of the program, estimated to be about \$4000 per tagged fish, are supported to a large extent by donations from anglers. For details, see: <http://www.preschallenge.com/aab/aab.html>

CIMAS FELLOWS

The Fellows provide guidance to the Director on matters concerning the ongoing activities and future direction of CIMAS. There are currently 19 Fellows, 12 from RSMAS and 7 from the local NOAA laboratories. Normally membership is approximately balanced between RSMAS and NOAA. But because of several changes during the past year, NOAA is currently underrepresented. This issue will be addressed during Year 5 of the Cooperative Agreement. In addition to the regular members, The Dean of RSMAS and the Directors of the NOAA laboratories are invited to attend on an *ex officio* basis.

The Fellows are typically scheduled to meet on a nominal quarterly basis although scheduling is sometimes difficult because of the extensive travel schedules. During Year 4 there were three formal meetings: 23 November 2004, 7 February 2005, and 17 April 2005. In addition many matters are implemented by means of email exchanges. Finally, because of the close proximity of the three Institutions and the frequent social activities, there are many ad hoc meetings and discussions.

FELLOWS

AFFILIATION

Dr. Bruce Albrecht	UM/RSMAS Meteorology and Physical Oceanography
Dr. James Bohnsack	NOAA/Southeast Fisheries Science Center
Dr. David J. Die	UM/RSMAS Marine Biology and Fisheries
Dr. Mark Donelan	UM/RSMAS Applied Marine Physics
Dr. Nelson Ehrhardt	UM/RSMAS Marine Biology and Fisheries
Dr. David Enfield	NOAA/AOML/Physical Oceanography
Dr. Rana A. Fine	UM/RSMAS Marine and Atmospheric Chemistry
Dr. Silvia Garzoli	NOAA/AOML/ Physical Oceanography
Dr. Kevin D. Leaman	UM/RSMAS Meteorology and Physical Oceanography
Dr. Frank Marks	NOAA/AOML/Hurricane Research Division
Dr. Christopher N.K. Mooers	UM/RSMAS Applied Marine Physics
Dr. Donald B. Olson	UM/RSMAS Meteorology and Physical Oceanography
Dr. Joseph E. Powers	NOAA/Southeast Fisheries Science Center
Dr. William J. Richards	NOAA/Southeast Fisheries Science Center
Dr. Claes G.H. Rooth	UM/RSMAS Meteorology and Physical Oceanography
Dr. Nick Shay	UM/RSMAS Meteorology and Physical Oceanography
Dr. Sharon S. Smith	UM/RSMAS Marine Biology and Fisheries
Dr. Rik Wanninkhof	NOAA/AOML/Ocean Chemistry Division
Dr. Rod Zika	UM/RSMAS Marine and Atmospheric Chemistry

Ex Officio

Dr. Otis B. Brown	UM/RSMAS Dean
Dr. Peter B. Ortner	NOAA/AOML/Ocean Chemistry Division
Dr. Nancy Thompson	NOAA/Southeast Fisheries Science Center

CIMAS AWARDS

Jerald S. Ault (UM/RSMAS)

- Winner, National Planning Award. Category: ‘*Outstanding Collaborative Planning Project or Program: Tortugas National Park General Management Plan*’. Federal Planning Division. American Planning Association. University of Illinois at Chicago. Recipients: National Park Service, Southeast Region; National Park Service, Denver Service Center; Dry Tortugas National Park; University of Miami, Rosenstiel School of Marine and Atmospheric Science; Florida Keys National Marine Sanctuary.

Jason Dunion (UM/CIMAS)

- Recipient: 2005 NOAA David Johnson Award for “innovative research using environmental satellite observations on the influence and impact of the Saharan Air Layer on Atlantic tropical cyclones and the role it plays in development, decay, and intensity change of these storms.”
- Recipient: AGU 2004 Editors’ Citation for Excellence in Refereeing for JGR-Atmospheres.

Michael J. LaGier (UM/CIMAS)

- Nominee (AOML) for 2005 Presidential Early Career Award for Scientists and Engineers.

Frank J. Millero (UM/RSMAS)

- Carnegie Mellon 2003 Alumni Distinguished Achievement Award.
- Sigma Xi, President-Elect, 2004-2006.

Joseph M. Prospero (UM/CIMAS)

- Selected as a University of Miami Distinguished Faculty Scholar.

POSTDOCTORAL FELLOWS AND GRADUATE STUDENTS

A total of 7 Postdoctoral Fellows and 12 Graduate Students were supported with NOAA funds through CIMAS in Year 4 of the Cooperative Agreement. These are listed below as "CIMAS Supported".

In addition, there are many Postdocs and Graduate Students associated with CIMAS program who are not supported through CIMAS. Many are Research Associates/Scientists who are pursuing graduate work at the University of Miami under the tuition-remission benefit or who are attending other local universities while carrying out their normal employment duties. Many of these are using research carried out in their work as a part of their thesis or dissertation. In addition, there are Postdocs and Graduate Students who are supported on funds from other sources but who are involved with CIMAS-related programs. The Postdocs and Graduate Students in this second category are listed below

In total, there are 22 Graduate Students and 19 Postdocs working on CIMAS related programs.

CIMAS-Supported Postdoctoral Fellows and Graduate Students

CIMAS Postdoctoral Fellows

Apostalaki, Panagiota
Baums, Iliana
Kang, Heesook
LaGier, Michael
Lueger, Heike
Valle-Esquivel, Monica
Vermeij, Mark

CIMAS Graduate Students

Barry, Thomas
Candace, Natasha
Chormaski, Scott
Darrah, Abigail
Deleveaux, Valliere
Framinan, Mariana
Jones, David
Freibaum, Joy
McClendon, Kristin
Moulding, Alison
Saul, Steven
Valliere, Deleveau

Other Postdoctoral Fellows and Graduate Students Associated with CIMAS Programs

Postdoctoral Fellows

Balotro, Rolando
Bellow, John
Breuer, Norman
Cabrera, Victor
Garcia y Garcia, Axel
Gerard-Marchant, Pierre
Guerra, Larry
Hodyss, Daniel
Huang, Xiaolan
Jones, David L.
Kuchinke, Christopher
Lueger, Heike
Liu, Xuewu
Pierrot, Denis
Shoosmith, Deborah
Wang, Zhaohui Alex
Zavala-Garay, Javier

Graduate Students

Carrasco, Nicholas
Chanson, Mareva
Davis, Natasha
Diaz-Consul, Celeste
Farmer, Nick
Forsee, William
Gerard, Trika
Hiscock, William
Larkin, Mike
Litz, Jenny
Luo, Hongli
McCrea, Ashley
Molina, Helena
Morisseau-Leroy, Nirva
Ranasingha, Maththondage Chamara
Ravitz, Guy
Sarinnapakorn, Kanoksri
Schiller, Rafael
Smith, Ryan
Stone, Holly
Swanson, Dione
Trapp, J. Michael
Sellwood, Kathryn
Uhlhorn, Eric
Vasquez Yeomans, Lourdes
Whitcraft, Samantha
Wicker, Jesse A.
Woodworth, Phoebe A.
Zhang, Jun

RESEARCH STAFF

Abercombie, Debra	Research Associate I
Absten, Michael	Research Associate I
Carrasco, Hector N.	Research Associate I
DiNezio, Pedro	Research Associate I
Dunion, Jason	Senior Research Associate III
Florit, Louis	Research Associate II
Fonseca, Carlos	Research Associate I
Forteza, Elizabeth	Research Associate I
Garcia, Claudia	Research Associate I
Garcia, Rigoberto	Research Associate I
Gramer, Lewis	Research Associate I
Hall, Jeremy	Research Associate I
Huang, Xialoan	Senior Research Associate II
Izaguirre, Miguel	Research Associate II
Jankulak, Michael	Research Associate II
Kates, Benjamin	Research Associate I
Kelble, Christopher	Senior Research Associate I
Lara, Monica	Assistant Scientist
Lee, Sang-Ki	Assistant Scientist
Litz, Jenny	Research Associate II
Lumpkin, Claude	Assistant Scientist
Mason, Benjamin	Research Associate I
Meinen, Christopher	Assistant Scientist
Melo, Nelson	Research Associate I
Mestas-Nunez, Alberto	Associate Scientist
Morisseau-Leroy, Nirva	Assistant Scientist
Otero, Sonia	Research Associate II
Rawson, Grant	Research Associate II
Redman, Jessica	Research Associate I
Stokes, Lesley	Research Associate II
Stone, Holly	Senior Research Associate II
Sullivan, Kevin	Senior Research Associate II
Uhlhorn, Eric	Research Associate I
Valde, Krystal	Research Associate I
Whitcraft, Samantha	Research Associate II
Wicker, Jesse	Research Associate I
Williams, Dana	Assistant Scientist
Xia, Xiangdong	Research Associate II
Yang, Huiqin	Senior Research Associate I
Yao, Qi	Research Associate II

VISITING SCIENTISTS

Dr. Tim Dumonceaux
Department of Animal and Poultry Science
51 Campus Drive
University of Saskatchewan
Saskatoon SK
23 - 26 March 2005
"Molecular enumeration of intestinal bacteria using quantitative PCR and the chaperonin-60 target"

Dr. Truls Johannessen
Professor
International Visiting Scientist
Geophysical Institute and Bjerknes
Centre for Climate Research
University of Bergen
Bergen, Norway
1 July 2004 - 30 June 2005
"The Tracer Experiment and the Carbon Cycle in the Nordic Seas"

Dr. Ricardo P. Matano
Associate Professor
College of Oceanic and
Atmospheric Sciences
Oregon State University
Corvallis, OR
20 - 30 March 2005
a. "The seasonal variability of the South Indian Ocean: models and observations"
b. "Notes on the low-frequency variability of the South Atlantic Ocean"

Dr. Fritz Schott
IfM-GEOMAR
Leibniz-Institut für Meereswissenschaften
Kiel, Germany
1 February - 24 March 2005
"Variability of the tropical-subtropical overturning circulation: observations and models"

Dr. Shang-Ping Xie
Professor
University of Hawaii
International Pacific Research Center Honolulu, HI
1 - 10 February 2005
a. "Observations and Modeling of Eastern Pacific Ocean-Atmosphere Interaction"
b. "Seasonal and Interannual Variability of Tropical Atlantic Climate"

Dr. Huijie Xue
Associate Professor
School of Marine Sciences
University of Maine
Orono, ME
27 February - 5 March 2005
"Coastal Ocean Forecast-The Gulf of Maine Story"
"Assessment of the GoMoos Nowcast/Forecast System"

Dr. Dongxiao Wang
South China Sea Institute of
Oceanology
Chinese Academy of Sciences
L64 West Xingang Road
Guangzhou
China 510301
International Visiting Scientist
1 January - 1 March 2005

Dr. Weiqiang Wang
South China Sea Institute of
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Chinese Academy of Sciences
L64 West Xingang Road
Guangzhou
China 510301
International Visiting Scientist
January 2005 – January 2006

PUBLICATIONS

We list all publications for the years 2004 – 2005, presented in categories. The category “Conference Proceedings” only lists publications that derive from presentations at meetings; it does not include oral presentations.

In Table 1 we summarize the record of publications over the period 2004 – 2005, listed as “peer reviewed” and “non-peer reviewed. The table also shows the distribution of lead author affiliation (CIMAS, NOAA scientist, or other institution).

Table 1: Publication Record 2004 - 2005

	Institute Lead Author				NOAA Lead Author				Other Lead Author			
	2001-02	2002-03	2003-04	2004-05	2001-02	2002-03	2003-04	2004-05	2001-02	2002-03	2003-04	2004-05
Peer Reviewed	54	60	36	34	0	7	14	14	--	--	30	33
Non Peer Reviewed	7	8	34	10	0	3	17	11	--	--	28	6

Refereed Journal Articles

Acero A, W. Richards, F. Amaya, and M.M. Criales (2005), First Caribbean record of *Akko dionaea* (Pisces: Gobiidae), another South American endemic, *Aqua*, 9(4), 133-138.

Ansorge, I, S. Speich, J. Lutjeharms, G. Goni, C. de W. Rautenbach, P. Froneman, and S. Garzoli (2005), Monitoring the oceanic flow between Africa and Antarctica: Report of the first GoodHope cruise, *South African Journal of Science*, 101, 29-35.

Arimoto, R., X.Y. Zhang, B.J. Huebert, C.H. Kang, D.L. Savoie, J.M. Prospero, S.K. Sage, C.A. Schloesslin, H.M. Khaing and S.N. Oh, Chemical Composition of Atmospheric Aerosols from Zhenbeitai, People's Republic of China, and Gosan, South Korea, during the ACE-Asia, *J. Geophys. Res.*, 109, D19S04, doi:10.1029/2003JD004323, 2004.

Ault, J.S., Bohnsack, J.A., Smith, S.G., and J. Luo (2005a), Towards sustainable multispecies fisheries in the Florida USA coral reef ecosystem, *Bull. Mar. Sci.*, 76(2):595-622.

Ault, J.S., Smith, S.G., and J.A. Bohnsack (2005b), Evaluation of average length as an indicator of exploitation status for the Florida coral reef fish community, *ICES J. Mar. Sci.*, 62, 417-423.

Ault, J.S., Smith, S.G., Bohnsack, J.A., Luo, J., Harper, D.E., and D.B. McClellan (2005c), Building sustainable fisheries in Florida's coral reef ecosystem: positive signs in the Dry Tortugas, *Bull. Mar. Sci.*, in press.

Bohnsack, J.A., Ault, J.S., and B. Causey (2004), Why have no-take marine protected areas? *American Fisheries Society Symposium*, 42, 185-193.

Cabrera, V.E., N.E. Breuer, P.E. Hildebrand, and D. Letson (2005), The dynamic North Florida dairy farm model: a user friendly computerized tool for increasing profits while minimizing environmental impacts under varying climatic conditions, *Computers and Electronics in Agriculture*, in press.

- Cabrera, V.E., P.E. Hildebrand, and J.W. Jones (2005), Modelling the effect of household composition on the welfare of limited-resource farmers in Coastal Cañete, Peru, *Agricultural Systems*, in press.
- Chiapello, I., C. Moulin, and J.M. Prospero, Understanding the long-term variability of African dust transport across the Atlantic as recorded in both Barbados surface concentrations and largescale Total Ozone Mapping Spectrometer (TOMS) optical thickness. *J. Geophys. Res.*, 110, D18S10, doi:10.1029/2004JD005132, 2005.
- Clement, A.C., and B. J. Soden (2005), The sensitivity of the tropical-mean radiation budget, *J. Climate*, in press.
- Coale, K.H., K. S. Johnson, F. P. Chavez, K. O. Buesseler, R. T. Barber, M. A. Brzezinski, W. P. Cochlan, F. J. Millero, P. G. Falkowski, J. E. Bauer, R. H. Wanninkhof, R. M. Kudela, M. A. Altabet, B. E. Hales, T. Takahashi, M. R. Landry, R. R. Bidigare, X. Wang, Z. Chase, P. G. Strutton, G. E. Friederich, M. Y. Gorbunov, V. P. Lance, A. K. Hilting, M. R. Hiscock, M. Demarest, W. T. Hiscock, K. F. Sullivan, S. J. Tanner, R. M. Gordon, C. N. Hunter, V. A. Elrod, S. E. Fitzwater, J. L. Jones, S. Tozzi, M. Koblizak, A. E. Roberts, J. Herndon, J. Brewster, N. Ladizinsky, G. Smith, D. Cooper, D. Timothy, S. L. Brown, K. E. Selph, C. C. Sheridan, B. S. Twining, and Z. I. Johnson (2004), Southern Ocean Iron Enrichment Experiment: Carbon Cycling in High- and Low-Si Waters, *Science*, 304, 408-414.
- Cosca, C.E., R.A. Feely, J. Boutin, J. Etcheto, M.J. McPhaden, F.P. Chavez, and P.G. Strutton (2003), Seasonal and interannual CO₂ fluxes for the Central and Eastern Equatorial Pacific Ocean as determined from fCO₂-SST relationships, *J. Geophys. Res.*, 108, 3278, doi: 10.1029/2000JC000677.
- Criales, M.M., J. Wang, J.A. Browder and M. Robblee (2005), Tidal and seasonal effect on transport of pink shrimp postlarvae, *Mar. Ecol. Prog. Ser.*, 286, 231-238.
- Criales, M.M., J. Wang, J.A. Browder, M. Robblee, T. Jackson, and C. Hittle (2005), Variability in supply and cross-shelf transport of pink shrimp postlarvae into western Florida Bay, *Fish. Bull.*, in press.
- DeMaria, M. Mainelli M., L.K. Shay, J.A. Knaff, and J. Kaplan (2005), Further improvements to the statistical hurricane intensity prediction scheme (SHIPS), *Wea. and Forecasting*, 20(4), 531-543.
- Dunion, J.P., and C.S. Velden (2004), The impact of the Saharan Air Layer on Atlantic tropical cyclone activity, *Bull. Amer. Meteor. Soc.*, 85(3), 353-365.
- Enfield, D.B. and S.-K. Lee (2005), The Heat Balance of the Western Hemisphere Warm Pool, *J. Clim.* 18, 2662-2681.
- Epstein, N., M.J.A. Vermeij, R.P.M. Bak, and B. Rinkevich (2005), Alleviating impacts of anthropogenic activities by traditional conservation measures: can a small reef reserve be sustainably managed? *Biol. Conserv.*, 121, 243-255.
- Feely, R.A., R. Wanninkhof, W.R. McGillis, M.-E. Carr, and C.E. Cosca (2004), Effects of wind speed and gas exchange parameterizations on the air-sea CO₂ fluxes in the equatorial Pacific Ocean, *J. Geophys. Res.*, 109, C08S03, doi:10.1029/2003JC00-1896.
- Feely, R.A., T. Takahashi, R. Wanninkhof, M.J. McPhaden, C.E. Cosca, and S.C. Sutherland, (2005), Decadal variability of the air-sea CO₂ fluxes in the equatorial Pacific Ocean, *J. Geophys. Res.*, accepted.
- Feely, R.A., C.L. Sabine, K. Lee, W. Berelson, J. Kleypas, V.J. Fabry, and F.J. Millero (2004), Impact of anthropogenic CO₂ on the CaCO₃ system in the oceans, *Science*, 305, 362-366.

- Feely, R.A., T. Takahashi, R., Wanninkhof, M.J. McPhaden, C.E. Cosca, and S.C. Sutherland (2005), Decadal variability of the air-sea CO₂ fluxes in the equatorial Pacific Ocean, *J. Geophys. Res.*, accepted.
- Fonseca, C., G.J. Goni, W. Johns, and E. Campos (2004), Investigation of the North Brazil Current retroflection and North Equatorial Countercurrent variability, *Geophys. Res. Lett.*, 31(21), L21304, doi:10.1029/2004GL020054.
- Ginoux, P., J.M. Prospero, O. Torres, and M. Chin, Longterm simulation of dust distribution with the GOCART model: Correlation with the North Atlantic Oscillation. *Environmental Modeling and Software*, 19, 113-128, 2004.
- Guerra, L. C., G. Hoogenboom, V. K. Boken, J. E. Hook, D. L. Thomas, and K. A. Harrison (2005), Evaluation of the EPIC model for simulating crop yield and irrigation demand, *Trans. ASAE* 47, in press.
- Hu, C., F.E. Muller-Karger, C. Taylor, K. L. Carder, C. Kelble, E. Johns, and C. A. Heil (2005), Red tide detection and tracing using MODIS fluorescence data: A regional example in SW Florida coastal waters, *Remote Sensing of the Environment*, in press.
- Hu, C., F. E. Muller-Karger, G. A. Vargo, M. B. Neely, and E. Johns (2004), Linkages between coastal runoff and the Florida Keys ecosystem: A study of a dark plume event, *Geophys. Res. Lett.*, 31, 15307-15310.
- Hu, C., J. R. Nelson, E. Johns, Z. Chen, R. H. Weisberg, and F. E. Muller-Karger (2005), Mississippi River water in the Florida Straits and in the Gulf Stream off Georgia in summer 2004, *Geophys. Res. Lett.*, 32, 14606-14610.
- Huang, X.-L., Y. Chen, and M. Shenker (2005), Rapid whole-plant bioassay for phosphorus phytoavailability in soils, *Plant and Soil*, 271(1-2), 365-376.
- Huang, X., B.J. Soden, and D.L. Jackson (2005), Interannual co-variability of tropical temperature and humidity: a comparison of model, reanalysis data and satellite observation, *Geophys. Res. Lett.*, in press.
- Jickells, T.D., Z.A. An, A.R. Baker, G. Bergametti, N. Brooks, P. W. Boyd, R.A. Duce, K.A. Hunter, C. Junji, H. Kawahata, N. Kubilay, K. K. Andersen, J. laRoche, P.S. Liss, N. Mahowald, J. M. Prospero, A.J. Ridgwell, I. Tegen, R. Torres, Global iron connections: Desert dust, ocean biogeochemistry and climate. *Science*, 308, 67-71, 2005.
- Kaandorp, J.A., P.M.A. Sloom, R.P.M. Bak, C. Maier, and M.J.A. Vermeij (2005), Modelling three dimensional growth forms in scleractinian corals, *Proc. Roy. Acad. Sci. (UK)*, 272, 127-133.
- Ka'eo, K., and S. Whitcraft (2004), The Kaho'olawe Island Reserve: a native Hawaiian approach to marine resources management, *Current; J. Mar. Education.*, 20, 26-29.
- Kang, H.S. and C.N.K. Mooers (2005), Diagnoses of simulated water-mass subduction/ formation/ transformation in the Japan/East Sea (JES), *Deep Sea Res. II*, in press.
- Key, R.M., A. Kozyr, C.L. Sabine, K. Lee, R. Wanninkhof, J. Bullister, R.A. Feely, F. Millero, C. Mordy, T.-H. Peng (2004), A global ocean carbon climatology: Results from GLODAP, *Global Biogeochem. Cycl.*, 18, GB4031, doi:10.1029/2004GB-002247.
- Kuchinke, C.P., H.R. Gordon, and K.J. Voss (2005), A coupled oceanic and atmospheric spectral optimization algorithm for application to ocean color satellites – sensitivity to near infrared error, IN R.J. Frouin, H. Kawamura, D. Pan; Eds., Active and Passive Remote Sensing of the Oceans, *Proceedings of SPIE*, 5656-38, 92-103, doi: 10.1117/12.579378.

- LaGier, M.J., C. Scholin, J. Wang, J.W. Fell, and K.D. Goodwin (2005), An electrochemical RNA hybridization assay for detection of the fecal indicator bacterium *Escherichia coli*, *Marine Pollution Bulletin*, doi:10.1016/j.marpolbul.2005.04.034, available online May 25.
- Landsea, C.W., J.L. Franklin, C.J. McAdie, J.L. Beven III, J.M. Gross, B.R. Jarvinen, R.L. Pasch, E.N. Rappaport, J.P. Dunion, and P.P. Dodge (2004), Reanalysis of Hurricane Andrew's intensity, *Bull. Amer. Meteor. Soc.*, 85(11), 1699-1712.
- Lee, S.-K., D.B. Enfield and C. Wang (2005), Ocean general circulation model sensitivity experiments on the annual cycle of Western Hemisphere Warm Pool, *J. Geophys. Res.*, in press.
- Lentini C., G. Goni, and D. Olson (2005), Investigation of Brazil Current rings in the Confluence region, *J. Geophys. Res.*, in press.
- Letson, D, G. Podestá, C. Messina and R. Ferreyra (2005), The Uncertain Value of Even Perfect ENSO Phase Forecasts, *Climatic Change* 63, 163-196.
- Lüger, H., D.W.R. Wallace, A. Körtzinger, and Y. Nojiri (2004), The pCO₂ variability in the midlatitude North Atlantic Ocean during a full annual cycle, *Global Biogeochem Cycl.*, 18, doi:10.1029/2003GB002200.
- Mahowald, N.M., A.R. Baker, G. Bergametti, N. Brooks, T.D. Jickells, N. Kubilay, R.A. Duce, J.M. Prospero, I.Tegen, The atmospheric global dust cycle and iron inputs to the ocean. *Global Biogeochem. Cycl.*, in press.
- Meester, G.A., Mehrotra, A., Ault, J.S., and E.K. Baker (2004), Designing marine reserves for fishery management, *Management Science*. 50(8):1031-1043.
- Meinen, C.S., S.L. Garzoli, W.E. Johns, and M.O. Baringer (2004), Transport Variability of the Deep Western Boundary Current and the Antilles Current off Abaco Island, Bahamas, *Deep Sea Res. I*, 51(11), 1397-1415.
- Mestas-Núñez, A.M., C. Zhang, and D.B. Enfield (2005), Uncertainties in estimating moisture fluxes over the Intra-Americas Sea, *J. Hydrometeorology*, in press.
- Miralles-Wilhelm, F., P. Trimble, G.P. Podestá, D. Letson, and K. Broad (2005), Climate-Based Estimation of Inflow into Lake Okeechobee, FL, American Society of Civil Engineers, *J. Water Resources Planning and Management* 131, 1-10.
- Olsen, A., J. Triñanes, and R. Wanninkhof (2004), Sea-air flux of CO₂ in the Caribbean Sea estimated using in situ and remote sensing data, *Remote Sensing Environ.*, 89, 309-325.
- Olsen, A., R. Wanninkhof, J.A. Trinanes, and T. Johannessen (2005), The effect of wind speed products and wind speed-gas exchange relationships on interannual variability of the air-sea CO₂ gas transfer velocity, *Tellus*, 57B, 95-106.
- Podestá, G.P., L. Núñez, C.A. Villanueva, and M.A. Skansi (2004), Estimating daily solar radiation in the Argentine Pampas, *Agricul. Forest Meteorol.* 123, 41-53.
- Sabine, C.L., R.A. Feely, N. Gruber, R. Key, K. Lee, J.L. Bullister, R. Wanninkhof, C.S. Wong, D.W.R. Wallace, B. Tilbrook, F.J. Millero, T.-H. Peng, A. Kozyr, T. Ono, and A.F. Rios (2004), The oceanic sink for anthropogenic CO₂, *Science*, 305, 367-371.
- Soden, B.J, A.J. Broccoli, and R.S Hemler (2004), On the use of cloud forcing to estimate cloud feedback, *J. Climate*, 19, 3661-3665.

- Takahashi, T., S.C. Sutherland, R.A. Feely, and C.E. Cosca (2003), Decadal variation of surface water pCO₂ in the Western and Central Equatorial Pacific, *Science*, 302, 852-856.
- Thacker, W. C. (2005), Estimating salinity to complement observed temperature: 1. Gulf of Mexico, *J. Mar. Sys.*, in press.
- Thacker, W.C. (2005), Estimating salinity to complement observed temperature: 2. Northwestern Atlantic, *J. Mar. Sys.*, in press.
- Vásquez-Yeomans, L. M.R. Lara, E. Sosa-Cordero, J.A. Cohuo, and R. Herrera (2005), Occurrence Of *Albula vulpes* leptocephali in the Mexican Caribbean, *Caribbean Journal of Science*, in press.
- Velden, C.S., J. Daniels, D. Stettner, D. Santek, J. Key, J.P. Dunion, K. Holmlund, G. Dengel, W. Bresky, and W.P. Menzel (2004), Recent innovations in deriving tropospheric winds from meteorological satellites, *Bull. Amer. Meteor. Soc.*, 86(2), 205-223.
- Vermeij, M.J.A. (2005), Substrate characteristics and adult density determine recruitment patterns in a Caribbean brooding coral, *Mar. Ecol. Prog. Ser.*, 295, 123-133.
- Vermeij, M.J.A. (2005), Early life-history dynamics of Caribbean coral species on artificial substratum: the importance of competition, growth and variation in life-history strategy, *Coral Reefs*, in press.
- Vermeij, M.J.A. (2005), A novel growth strategy allows *Tubastrea coccinea* to escape small-scale adverse conditions and start over again, *Coral Reefs*, in press.
- Vermeij, M.J.A., N.D. Fogarty, and M.W. Miller (2005), Variable planktonic conditions affect larval behavior, survival, and settlement patterns in the Caribbean coral *Montastraea faveolata*, *Mar. Ecol. Prog. Ser.*, in press.
- Walsh, J.J., J.K. Jolliff, B.P. Darrow, J.M. Lenes, S.P. Milroy, D.A. Dieterle, K.S. Carder, F.R. Chen, G.A. Vargo, R.H. Weisberg, K.A. Fanning, F.E. Muller-Karger, K.A. Steidinger, C.A. Heil, C.R. Tomas, J.M. Prospero, R.N. Lee, G.J. Kirkpatrick, T.E. Whitledge, D.A. Stockwell, T.A. Villareal, A.E. Jochens, and S.P. Bontempi, Red tides in the Gulf of Mexico: where, when, and why?, *J. Geophys. Res.*, in press.
- Wang, J.D., Luo, J., and J.S. Ault (2004), Flows, salinity, and some implications for larval transport in south Biscayne Bay, Florida, *Bull. Mar. Sci.*, 72(3):695-723.
- Wanninkhof, R., K.F. Sullivan, and Z. Top (2004), Air-sea gas transfer in the Southern Ocean, *J. Geophys. Res.*, 109, C08S19, doi:10.1029/982 2003JC001767.
- Wanninkhof, R., K.F. Sullivan, and Z. Top (2004), Air-sea gas transfer in the Southern Ocean, *J. Geophys. Res.*, 109, C08S19, doi:10.1029/982 2003JC001767.
- Ward, B., R. Wanninkhof, W.R. McGillis, A.T. Jessup, M.D. Degrandpre, J.E. Hare, and J.B. Edson (2004), In the air-sea flux of CO₂ resulting from ocean surface temperature gradients during GasEx-2001, *J. Geophys. Res.*, 109, doi:10.1029/ 2003JC001800.
- Watson, J.W., S.P. Epperly, A.K. Shah, and D.G. Foster (2005), Fishing Methods to Reduce Sea Turtle Mortality Associated with Pelagic Longlines, *Canadian Journal of Fisheries and Aquatic Science*, 62(5): 965-981.
- Williams, D.E., and P. Hallock (2004), Light requirements and bleaching in *Amphistegina gibbosa* d'Orbigny: Observations from laboratory experiments, *Mar. Biol.*, 145, 641-649.

Publications

- Williams, D.E., and M.W. Miller (2005), Coral disease outbreak: pattern, prevalence, and transmission, *Mar. Ecol. Prog. Ser.*, in press.
- Zavala-Garay J., C. Zhang, A. M. Moore, and R. Kleeman (2005), The linear response of ENSO to the Madden-Julian Oscillation, *J. Clim.*, 18(13), 2441-2459.

Books and Chapters-in-Books

- Criales, M. M. (2005), Preliminary guide to the identification of the early life history stages of cirrhitid fishes of the western central north Atlantic. In *Early Stages of Atlantic Fishes: An Identification Guide for Western Central North Atlantic*, edited by W. Richards, Taylor & Francis Books, Inc.
- Drennan, W.M. (2005), On parameterisations of air-sea fluxes, in *Atmosphere-Ocean Interactions*, Vol. 2, edited by W. Perrie, WIT Press, in press.
- Hendee, J.C., E. Stabenau, L. Florit, D. Manzello, and C. Jeffris (2005), Infrastructure and capabilities of a near real-time meteorological and oceanographic in situ instrumented array, and its role in marine environmental decision support, in *Remote Sensing of Aquatic Coastal Ecosystem Processes*, edited by L. Richardson and E. leDrew, Kluwer Academic Publishers, in press.
- Ingram, K.T. (2005), Agricultural drought and its effects on important food crops, in *Agricultural Drought Monitoring Strategies in the World*, edited by V.K. Boken, Oxford Univ. Press, New York, in press.
- Landsea, C.W., C. Anderson, N. Charles, G. Clark, J.P. Dunion, J. Fernandez-Partagas, P. Hungerford, C. Neumann, and M. Zimmer (2004), The Atlantic Hurricane Database Reanalysis Project: Documentation for the 1851-1910 alterations and additions to the HURDAT Database, Columbia University Press, 462 pp.
- Laroche, W.A., J.G. Ditty, J.T. Lamkin, and S.R. Whitcraft (2004), CARANGIDAE: Jacks. *Early Stages of Atlantic Fishes: an identification guide for the western central North Atlantic*, edited by W. J. Richards, CRC Press, Boca Raton, Florida, in press.
- Millero, F.J. (2005), Chemical Oceanography, 3rd Edition, CRC Press.
- Shay, L.K., and S.D. Jacob (2005), Relationship between oceanic energy fluxes and surface winds during tropical cyclone passage, In Atmosphere-Ocean Interactions II, in *Advances in Fluid Mechanics.*, edited by W. Perrie, WIT Press, Southampton, UK, 31 pp., in press.
- Whitcraft, S.R., and M.R. Lara (2005), GIBBERICHTHYIDAE: Gibberfishes. *Early Stages of Atlantic Fishes: an identification guide for the western central North Atlantic*, edited by W. J. Richards, CRC Press, Boca Raton, Florida, in press.
- Zhu, W., J. Almaraz, G. Campbell, H. Hammad, N. Morisseau-Leroy, B. Paton (2004), Implementing Web Applications With CM Information Integrator for Content and OnDemand Web Enablement Kit, IBM Redbooks publisher, July 2004.

Conference Proceedings

- Black, M., J.P. Dunion, J. Kossin, W. Schubert, C.S. Velden, P.G. Black, R. Zehr, and S. Aberson (2004), Mesovortices in Hurricane Isabel (2003): A comparison of satellite, radar, and photographic observations, *AMS 26th Conference on Hurricanes and Tropical Meteorology*, Miami, FL, American Meteorological Society, 128-129.
- Dunion, J.P., C.S. Velden, J.D. Hawkins, and J.R. Parrish (2004), The Saharan Air Layer- Insights from the 2002 and 2003 Atlantic hurricane seasons, *AMS 26th Conference on Hurricanes and Tropical Meteorology*, Miami, FL, American Meteorological Society, 495-496.
- Epperly, S., L. Belskis, and L. Stokes (2005), Using Passive Integrated Transponder (PIT) RFID Equipment. Proceeding of the 25th Annual Symposium on Sea Turtle Biology and Conservation, February 2005, Savannah, Georgia. NOAA Tech. Memo, NMFS_SEFSC, in press.
- Hallock-Muller, P, D.E. Williams, S.K. Toler, E.M. Fisher, and H.K. Talge (2005), Bleaching in reef-dwelling foraminifers: implications for reef decline, *Proc 10th Intl. Coral Reef Symp.*, in press.
- Humston, R., Olson, D.B., and J.S. Ault (2004), Behavioral assumptions in models of fish movement and their influence on population dynamics, *Transactions of the American Fisheries Society*, 133, 1304-1328.
- Kaandorp, J.A., R.P.M. Bak, and M.J.A. Vermeij (2005), Modeling of nutrient gradients in three-dimensional images - and simulated morphologies of a branching coral, *Proc. 10th Int. Coral Reef Symp*, Okinawa, Japan, in press.
- Kossin, J.P., W.H. Schubert, C.S. Velden, M. Black, P.G. Black, R. Zehr, S. Aberson, and J.P. Dunion (2004), Mesovortices in Hurricane Isabel (2003), *AMS 26th Conference on Hurricanes and Tropical Meteorology*, 3-7 May, Miami Beach, FL, 447-448.
- Manzello, D., J. Hendee, D. Ward, and Z. Hillis-Star, (2005), An Evaluation of Environmental Parameters Coincident with the Partial Bleaching Event in St. Croix, U.S. Virgin Islands 2003, *Proceedings of the 10th International Coral Reef Symposium*.
- Moore, C. N. K., C. S. Meinen, M. O. Baringer, I. Bang, R. Rhodes, C. N. Barron, and F. Bub (2005), Cross Validating Ocean Prediction and Monitoring Systems, *EOS*, 86(29), 269, 272-273.
- Nolan, D. S., M. A. Bender, T. P. Marchok, S. T. Garner, and C. L. Kerr (2003), Simulations of Hurricane Isabel (2003) in the WRF, GFDL, and ZETAC models, *Proceedings of the 5th WRF Users Conference*, Boulder, Colorado, June 2004.
- Stabenau, E., J. Hendee and L. Florit (2005), Techniques for the automated assessment of intense light and high sea temperature on coral response, *Proceedings of the 10th International Coral Reef Symposium*, in press.
- Uhlhorn, E. W., and L.K. Shay (2004), Analysis of upper-ocean thermodynamic observations forced by Hurricane Lili, *AMS 26th Conference on Hurricane and Tropical Meteorology*, 3-7 May, Miami Beach, FL, 619-620.
- Wanninkhof, W., and F.J. Millero, SeaKeepers network to study sea's role in absorbing Greenhouse Gases, *Showboats International*, 71, January 2004.
- Williams, D.E., and M.W. Miller (2005), Importance of disease and predation to the growth and survivorship of juvenile *Acropora palmata* and *Acropora cervicornis*: a demographic approach, *Proc. 10th Int Coral Reef Symp.*, in press.

Publications

Technical Reports

- Ault, J.S., Zurcher, N., Franklin, E.C., Smith, S.G., and J. Luo (2004), A strategy for managing marine ecological resources in Dry Tortugas National Park. Final Report to National Park Service, 75 pp.
- Ault, J.S., Begg, G., Gribble, N., Kulbicki, M., Mapstone, B., and P. Medley (2004), Coral reef fish stock assessment workshop. Expert Panel Report, Western Pacific Fishery Management Council, Honolulu, HI, 35 pp.
- Ault, J.S., Smith, S.G., McClellan, D., Zurcher, N., Franklin, E.C., and J.A. Bohnsack (2004), An aerial survey method for estimation of boater use in Biscayne National Park during 2003-2004. Final Report to the National Park Service, 44 pp.
- Ault, J.S., Smith, S.G., and W.B. Perry (2005), Fishery resource habitat use modeling in Florida Bay: development and application to Everglades restoration implementation, Technical Report to National Park Service and NOAA, 27 pp.
- Ault, J.S., Smith, S.G., Bohnsack, J.A., and J. Luo (2005), Fishery-independent monitoring of coral reef fishes and macroinvertebrates in the Dry Tortugas. Final Report to the National Park Service, FL Keys National Marine Sanctuary, and NOAA Fisheries, 59 pp.
- Ault, J.S. et al. (2005), Contributors to NOAA Technical Memorandum NOS NCCOS 11 '*The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2005*'.
- Barham, J., Y. Gichon, S. Humphries, F. Rossi, D. Alvira, A. Rios, P.E. Hildebrand, V.E. Cabrera, and N. Breuer (2004), Assessment of the format, content, and potential uses of the AgClimate website and crop yield risk assessment tool by extension agents in North Florida, Southeast Climate Consortium Technical Report Series: SECC-04-001. Gainesville, FL.
- Beerkircher, L.R., C.J. Brown, D.L. Abercrombie, and D.W. Lee (2004), SEFSC Pelagic Longline Observer Program data summary for 1992-2002, NOAA Technical Memorandum NMFS-SEFSC-522, 25 p.
- Bender, M., S. Doney, R.A. Feely, I.Y. Fung, N. Gruber, D.E. Harrison, R. Keeling, J.K. Moore, J. Sarmiento, E. Sarachik, B. Stephens, T. Takahashi, P.P. Tans, and R. Wanninkhof (2002), A large Scale Carbon Observing plan: In Situ Oceans and Atmosphere (LSCOP), pp. 201, Nat. Tech. Info. Services, Springfield, VA.
- Black, P. G., M. D. Powell, and E. W. Uhlhorn (2004), Report to the National Hurricane Center regarding the performance of the Stepped Frequency Microwave Radiometer during the landfalls of Hurricanes Ivan and Jeanne, *Tech. Rep.*, 9 pp., NOAA/AOML/Hurricane Research Division, Miami, FL.
- Breuer, N., P. Gilreath, G. McAvoy, D. Letson, and C. Fraisse (2004), Using seasonal climate variability forecasts: Risk management for tomato production in South Florida. Florida Cooperative Extension Services, Gainesville, FL. IFAS Publication CIR 1450. Available on-line at [<http://edis.ifas.ufl.edu/AE269>]
- Breuer, N., M. Langholtz, D. Zierden, and C. Fraisse (2004), Using seasonal climate variability forecasts to plan forest plantation establishment. Florida Cooperative Extension Services, Gainesville, FL. IFAS/EDIS publication ABE 354. Available on-line at [<http://edis.ifas.ufl.edu/AE282>].
- Carter, D.W., and D. Letson (2005), Recreational Fishing Effort, Harvest the Economy, and Climate: Red Snapper in the Gulf of Mexico, *Working Paper Series SEFSC-SSRG-06*, NOAA Southeast Fisheries Science Center Social Science Research Group, Miami, Florida.
- Contillo J., J. Tobias, B. Mase, J. Litz, and J. Wicker (2005), Photo-identification of Bottlenose Dolphins in Biscayne Bay, Florida 1990-2003, NOAA Technical Memorandum, in press.

- Criales, M.M., C.B. Paris, C. Yeung, D. Jones, W. Richards and T. Lee (2004), Horizontal and seasonal distributions of zooplankton biomass and fluorescence from MOCNESS plankton tow in the Florida Straits and the Dry Tortugas. *NOAA Tech. Mem.* NMFS-SEFSC-525. 24 pp.
- Feely, R.A., and C.L. Sabine (2002), A plan for data management of in situ large-scale oceanic carbon observations, pp. 21, OAR, Springfield VA.
- Fraisse, C., D. Zierden, N. Breuer, J. Jackson, and C. Brown (2004), Climate forecast and decision making in agriculture. Florida Cooperative Extension Services, Gainesville, FL, IFAS Publication ABE 352. Available on-line at [<http://edis.ifas.ufl.edu/AE267>].
- Hoogenboom, G., J.W. Jones, P.W. Wilkens, C.H. Porter, W.D. Batchelor, L.A. Hunt, K.J. Boote, U. Singh, O. Uryasev, W.T. Bowen, A.J. Gijsman, A. du Toit, J.W. White, and G.Y. Tsuji (2004), Decision Support System for Agrotechnology Transfer Version 4.0 [CD-ROM]. University of Hawaii, Honolulu, HI.
- Kourafalou, V.H., R.S. Balotro, and T.N. Lee (2005), The SoFLA-HYCOM (South Florida HYCOM) Regional Model around the Straits of Florida, Florida Bay and the Florida Keys. UM/RSMAS Tech. Rep. 2005/03, 28 pp.
- Kourafalou, V.H. (2005), SoFLA-HYCOM (South Florida HYCOM) Regional Model around the Straits of Florida, Florida Bay and the Florida Keys: An overview. (On line) Available: http://hycom.rsmas.miami.edu/overview/SoFLA_HYCOM.pdf
- Millero, F.J., T. Graham, X. Zhu, W. Hiscock, M. Trapp, D. Valdes, and V. Koehler (2004), Global Ocean Repeat Hydrographic Study: pH and Total Alkalinity Measurements in the North Atlantic (A16N Cruise June – August 2003), University of Miami Technical Report, No. RSMAS-2004-05.
- Millero, F.J., T. Graham, X. Zhu, M. Chanson, and V. Koehler (2004), Global Ocean Repeat Hydrographic Study: Total Alkalinity Measurements in the North Atlantic (A22 Cruise October – November 2003), University of Miami Technical Report, No. RSMAS-2004-06.
- Peltola, E., R. Wanninkhof, J.L. Bullister, N., Feely, R. Castle, D. Greeley, J.-Z. Zhang, F.J. Millero, and T. Graham (2004), CO₂ studies on a repeat hydrography cruise in the Atlantic Ocean: CO₂/CLIVAR section A16N_2003a during June-August 2003, ORNL.
- Sabine, C.L., R.M. Key, R. A. Feely, R. Wanninkhof, F.J. Millero, T.-H. Peng, J.L. Bullister, K. Lee, and A. Kozyr (2005), Global Ocean Data Analysis Project (GLODAP): Results and Data, ORNL/CDIAC-145, NDP-083, April 2005.
- Sabine, C.L., R.A. Feely, R.M. Key, R. Wanninkhof, F.J. Millero, T.-H. Peng, J.L. Bullister, and A. Kozyr (2005), Global Ocean Data Analysis Project (GLODAP): Results and Data, NOAA/PMEL Report Number 2776, February 2005.
- Stone, H.M., and D.W. Carter (2004), Methodology for Mapping Preliminary Data from Waves 6 and 1 of the 2003-2004 MRFSS Economic Add-On in Puerto Rico, *Mapping Document Series SEFSC-SSRG-MD-04*, NOAA Southeast Fisheries Science Center Social Science Research Group, Miami, Florida.
- Vedwan, N., K. Broad, D. Letson, K.T. Ingram, G. Podestá, N.E. Breuer, J.W. Jones, and J.J. O'Brien (2005), Assessment of climate information dissemination efforts by the Florida Climate Consortium, Southeast Climate Consortium Technical Report Series: SECC-05-01. Gainesville, FL.
- Wang, J.D., and J.A. Browder (2004), Simulation and Analysis of Monthly Salinity Patterns Resulting from Alternative Configurations of The Golden Gate Estates Restoration Project, Final Report to the SFWMD, Big Cypress Basin Board, 6089 James Lane, Naples, Florida.

Publications

Wanninkhof, R., T-H. Peng, B. Huss, C.L. Sabine, K. Lee (2003), Comparison of inorganic carbon system parameters measured in the Atlantic Ocean from 1990 to 1998 and recommended adjustments, *ORNL/CDIAC-140*, 43pp.

Wanninkhof, R. and F.J. Millero (2004), Seakeepers network to study sea's role in absorbing greenhouse gases, *Showboats International*, 71, Jan. 2004.

Master Theses

Franklin, E.C. (2004), Stock assessment of the Florida gray angelfish fishery, Masters Thesis, University of Miami, Coral Gables, FL, May 2004.

Robbins, R.J. (2005), Impacts of salinity fluctuations on the productivity of coastal mangrove fish populations, Ph.D. Dissertation, University of Miami, Coral Gables, FL, May 2005.

Zhang, Jun (2005), Humidity Flux Measurement in Hurricane Conditions, M.S. Thesis, University of Miami, Coral Gable, FL, May 2005



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